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[OFFICIAL NOTICE.]

## NEW ENGLAND ASSOCIATION OF GAS ENGINEERS.

The Annual Meeting of the Association will be held at Young's Hotel, Boston, on the 18th and 19th days of February, commencing at 10 o'clock, on Wednesday forenoon, February 18th.

Members intending to propose to the Association the names of applicants for membership are requested to send the same to the Secretary at least one day before the meeting.

The Directors will meet at the same place, on the evening of Feb. 17th, at 8 o'clock. Papers to be read before the Association should be forwarded to the Secretary, in season to be presented by him to the Directors at that meeting for their approval.

GEO. B. NEAL,
*Secretary.*

BOSTON, Jan. 24th, 1880.

## GAS MATTERS IN NEW YORK.

The nine-day's wonder of the Edison Lamp seems to have had its day, and now very little is heard of it, except an occasional short paragraph, either of promise or fun, in the daily papers, from which it would appear that the "perfect lamp" requires some further modification to make it just what is needed to supplant gas. In the meanwhile, there are some whispers in the street to the effect that some of the gas companies, at least, are not entirely satisfied with the present low price of gas. Two of the companies have declared dividends; but probably not from *earnings* during the past six months, but more likely from surplus on hand before the extreme reduction in price, or from funds derived from some other source. Certainly, no company with a stock capitals such as the New York companies have can be expected to earn and pay any dividend while selling gas at 75 cents to $1.50 per thousand. As to the policy of paying a dividend when it was not earned—we question the advisability of it. If it was a good thing to have a moderate surplus when good prices prevailed, it certainly seems to be a better thing to have it during a fight. There are one or two things that are quite encouraging in the situation to-day. The New York Mutual Company have called meetings of its stockholders for the purpose of securing a reduction in the capital stock of that company from five to three million dollars; and as it is understood that a very large majority of the stockholders are in favor of the reduction, it will probably be done, although, at this moment, we are not aware that all the details are arranged. This is a noble example, and we wish that the lead taken in this matter may be followed by many other companies who would seem to have a capital out of proportion to the business they are doing. A moderate capital is an absolute necessity in order to sell gas cheaply and make a fair profit, and cheap and good gas is what the consumer demands, while a fair profit on investment is what the stockholder is justly entitled to.

The Municipal Company, on the other hand, have called a meeting for the purpose of increasing their capital stock from two to three millions. This is said to be necessary for purposes of extension. Subsequently to the issue of the call for the above meeting, an explosion or accident occurred at the works of the Knickerbocker Company, Second avenue and Ninety-ninth street, and connections were made with the mains of the Municipal Company for the purpose of getting a supply for at least a part of the Knickerbocker's consumers.

The damage done by the explosion at the Knickerbocker's works is variously stated, all definite information being withheld by the company. The fact of their getting a partial supply, at least, outside, however, is undoubted; and another thing which transpired a few days later would seem to indicate that the damage was considerable—and that is that the Knickerbocker company is reported to have sold out entirely to the Municipal Company. If this is so it is another step in the right direction, for it practically consolidates two of the existing companies. The terms of the purchase are not made public; but it is a clever move on the part of the Municipal Company whether they continue the war of prices or not. The property and franchises are valuable, and it is not to be supposed that more was paid for them than they are worth. It simplifies the problem of ultimate amalgamation inasmuch as there is one less company to negotiate. It is to be sincerely hoped that further amalgamation will follow, and that the business will be placed in the hands of one organization, with less capital than is already represented by the stock of the various companies; and that, satisfied with dividends of ten per cent., the price of gas will yield that, and keep all the works and plant in thorough order. This once done, opposition will cease and mutual benefit accrue to all.

[From the London "Journal of Gas Lighting."]

## Gas Engines.

Sir—I have just learned that a letter of mine, on "Gas Engines," appeared in the last number of *Engineering*. As the subject is interesting to gas co.'s, and is treated in a novel way, perhaps you would find room for it in the *Journal*. It is a subject to which I may return, taking up the economical part of it. DENNY LANE.

*Cork Gas Consumers Company, Jan.* 13, 1880.

To the Editor of *Engineering*.

Sir—In all industries which require a small amount of motive power, the use of the gas engine is extending day by day. The fact that it is ready at a moment's notice without the delay caused by lighting fires or getting up steam, or the expense of keeping up the pressure during intervals of work, the small amount of attendance which it requires, and its immunity from danger of explosion, are some of the reasons that specially recommend it, On the other hand, it has not been long enough in use to enable practical men to decide on its probable durability, and the high temperature at which it works makes considerable doubt be entertained upon this point. In some kinds of engine the slide valve seems to undergo rapid deterioration. In some of the latter patterns, however, it is said that the valve is maintained at so low a temperature that no apprehension need be entertained upon this point. Again, up to the present the price charged for gas engines has been rather high, but competition will doubtless remedy this objection, and, indeed, of late some engines which have not as yet fully come into the market are advertised at prices remarkably low. If these engines are good they will be sold largely, not only for manufacturing but domestic purposes, and the pumping of water, the cleaning of cutlery and plate, the polishing of boots and shoes, etc., will ere long, not only in hotels, but even in private houses be performed by this handy and cheap "slave of the lamp."

My object in writing to you at present is to call the attention of your readers to the relative efficiency of the heat employed in the gas engine as compared with the steam engine.

All your readers are, of course, aware of the meaning of the mechanical equivalent of heat, or the quantity of dynamic energy that is equal to a thermal unit. I will employ the English mechanical unit—viz., a foot pound, or the quantity of work employed in raising 1 lb. 1 foot vertically, and the English thermal unit, or the quantity of heat which is sufficient to raise 1 lb. of water 1°F. I will call the first foot-pounds, and the second 0.

The mechanical equivalent of heat, as experimentally determined by Dr. Joule, and theoretically calculated by others, is 1 0=722 foot-pounds, that is to say, that if all the heat in one 0 unit were converted into work, this work would be equal to 772 foot-pounds; or 772 foot-pounds, if converted into heat, will produce one 0.

The large unit employed by engineers—viz., the horse power, is 33,000 foot-pounds, and therefore the thermal equivalent of the amount of work is $\frac{33{,}000 \times 60}{772}$=2563 0, or 2563 heat units are converted in producing 1 horse power.

It is calculated that good coal by its combustion generates 14,000 0. If all the heat could be converted into work, it would thus require only $\frac{2{,}563}{14{,}000}$=0.18 lb., or about one-sixth of a pound of coal to maintain 1-horse power for an hour.

We know that the best compound condensing engines use 2 lbs. of coal, a good ordinary condensing engine uses 5 lbs:, and small high-pressure engines from 4 lbs. to 10 lbs., and even more, per hour. It must be remembered that when the work is interrupted at night and at meal times, a considerable quantity of fuel is used in getting up and maintaing steam.

The economical result may be summed up as follows: Engines using the quantities of coal enumerated below, convert into work the following percentage of the total heat of combustion:

| | | | | | |
|---|---|---|---|---|---|
| Engines using | 2 lbs. | per horse power | convert | 9.0 | per cent. |
| " | 3 | " | " | 9.0 | " |
| " | 4 | " | " | 4.5 | " |
| " | 5 | " | " | 3.6 | " |
| " | 6 | " | " | 3.0 | " |
| " | 7 | " | " | 2.6 | " |
| " | 8 | " | " | 2.3 | " |
| " | 9 | " | " | 2.0 | " |
| " | 10 | " | " | 1.8 | " |

Let us now take the use of the gas engine. I will give four examples, taking the maker's statement as to the consumption of gas:

| | | | |
|---|---|---|---|
| I. | 20 | cubic feet | per hour. |
| II. | 15 | " | " |
| III. Not condensing | 15 | " | " |
| IV. Condensing | 10 | cubic feet, and 12 gallons of water. | |

There is considerable variation in the quality of coal gas. The higher the illuminating power, the higher also the heating power; but the latter quality increases in a less ratio than the former. For example, cannel gas of 26 candles is, for supplying light, 75 per cent. better than ordinary 15 candle coal gas, but some recent experiments show it only about 23 per cent. better for heating purposes.

Cannel gas of 33 candles, although 120 per cent. better for lighting than the first, is only about 50 per cent. better for heating.

In order to fix on some standard, I will take ordinary coal gas of, say, 16-candle power, such as is supplied in London. The heating power of coal gas has been variously estimated as under—

M. Morin, 696 0; Dr. Letheby, 650 0; Mr. Evans, 650 0; Mr. Goddard, 652 0; Mr. A. G. V. Harcourt, 756 0.

I am inclined to think that the latter estimate is nearer the average than the others. I will, however, assume 700 0, being the mean between the extremes given ebove, We, therefore, see that the gas engines mentioned above should develop by the combustion of gas—

| | | |
|---|---|---|
| No. 1 | (20×700) | =14,000 0 |
| Nos. II. and III | (15×700) | =10,500 0 |
| No. IV | (10×700) | = 7,000 0 |

If all the heat of combustion of 1 cubic foot of gas were converted into work, one horse power would require only $\frac{700}{2500}$=3.66 cubic feet per hour.

If we do as before, and divide 2563 0 by each of these numbers, we get the following results—

| | |
|---|---|
| No. 1. $\frac{2{,}563}{14{,}000}$ | = .183 |
| Nos. II. and III. | = .244 |
| No. IV. | = .366 |

Or, in other words, the percentage of the heat combustion converted into work is as follows—

| | |
|---|---|
| No. 1 gas engine converts | 18·3 per cent. |
| Nos. II. and III. gas engines convert | 24·4 " |
| No. IV. gas engine converts | 36·6 " |

If we contrast these percentages with those already given for the steam-engine, we find that No. I. converts into useful effect twice as much of the heat as the best steam engine, six times as much as a good condensing engine, and eleven times as much as small high pressure engines commonly employ. No IV. is said to turn into useful effect four, twelve and twenty-three times as much heat respectively as the three classes of steam-engines referred to.

These results seem remarkable for a machine which I may say, as compared with steam engine, is almost in its infancy, and it is almost possible that some special qualities of gas will hereafter be manufactured, at a low cost, for the production of heat and motive power. If such be the case the province of the gas engine will be far extended.

I will not at present go into the question of cost, but a friend of mine has remarked that a very important social change may arise from perfecting the gas engine. If the production of motive power on a *small* scale can be made economical, the small manufacturer may be able to compete with the great millowner, and the productions of the country may to a great extent come from men and women and children associated in families, and not from "hands" crowded together in great factories.

*Cork, Jan.* 5, 1880. DENNY LANE.

---

A correspondent has expressed his opinion that no gas engine has worked with so low a consumption as 10 cubic feet. I have given only the manufacturers statements. Allowing even 20 feet consumption, which has certainly been proved, the gas engine converts twice as much as the best steam engine and ten times as much as some small ones. If, as is frequently the case, the gas engine is tested by the friction brake, and the steam engine by the indicator, the former is unfairly over weighted to the extent of 20 or 25 per cent.

*Cork, Jan.* 22, 1880. DENNY LANE.

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TWO GAS COMPANIES UNITED.—The Municipal Gas Light Company, of this city, has purchased the property and franchises of the Knickerbocker Gas Light Company, which has mains in that portion of the city north of Thirty-fourth street, and a franchise to lay pipes anywhere in the city. The sale was consummated last week. The Knickerbocker Gas Light Company was an outgrowth of the old Union Company, which was sold under foreclosure of mortgage six or seven years ago, after beginning the building of works at Second avenue and East Ninety-ninth street. For several years the company did nothing, not even laying a main; but in June, 1878, certain capitalists of this city took hold of the Knickerbocker Company, and William A. Stevens, as president, was placed in charge of the completion of the work.—New York *Tribune*, Feb. 11th.

## On Water Gas from Coal and Petroleum.

### Its Calorific Energy and Intensity as Compared with Siemens' Gas and Coal.

By Herman Haupt, C.E., Honorary Member of the Club.

[The following is a paper read before the Engineers' Club of Philadelphia on January 3d, by Gen Herman Haupt, which is kindly furnished us for publication. As this article starts from a standpoint somewhat different from the usual one, we trust that it will receive careful consideration and be fully discussed in these columns.—Ed.]

*Is it possible to increase the calorific power of coal by converting it into water gas?* This possibility is very generally denied, and the reason assigned is that no greater calorific power can be developed in the reunion of elements than was exerted in effecting their dissociation.

Conceding the truth of this position, the answer is simply that it does not in any manner express the conditions of the question.

Suppose that two elements, the union of which is accompanied by a certain degree of calorific energy, shall have been dissociated by an application of force, the energy of reunion of the same elements may not, and probably will not, exceed the force exerted in the separation.

But suppose there is no reunion of the same elements, but that each of the separated elements forms a new union with two foreign elements, or with two new and different equivalents of a single element. Will there not be two operations, each developing an amount of energy equivalent to that which would attend the reunion of the two elements originally dissociated, and thus double the calorific development?

This is precisely the condition of things which exists in the case of water gas. Carbon, at a proper temperature, decomposes steam, with formation of equal volumes of carbonic oxide and hydrogen, each of these volumes requiring precisely the same amount of oxygen and developing the same number of heat units in combustion.

Now, it is conceded that if the dissociated hydrogen and oxygen are reunited, a degree of calorific energy will be developed not greater than was exerted in effecting their separation; but it must be remembered that there is another and equal volume of combustible gas, carbonic oxide, which requires another equal volume of oxygen supplied by air, which costs nothing, and in the union develops the same number of heat units as in the combustion of the hydrogen. Must not the theoretical calorific power, therefore, be doubled?

It will be interesting to pursue this investigation further, and compare the number of calorific units required to effect the dissociation of water by means of carbon with the number of units developed by reunion or combustion of the liberated hydrogen.

The calorific energy communicated to 1 lb. of carbon and 1¼ lbs. of water must be sufficient—

1st. To overcome the latent heat of carbon.

2d. To raise the temperature of the carbon to 2250°.

3d. To raise 1.5 lbs. of water vapor to 2250°.

*The latent heat of carbon.* One pound of carbon uniting with two equivalents, 2⅔ lbs., of oxygen, and burned to carbonic acid, develops 14,500 units. One pound of carbon in carbonic oxide, uniting with one equivalent, 1⅓ lbs. oxygen, develops 10,204 units. The difference is 4296 units, which represents the calorific energy of the union of 1 lb. solid carbon and one equivalent of oxygen.

It appears, therefore, that one pound of carbon, in the form of gas, uniting with one equivalent of oxygen, develops 10,204 units, but one pound of *solid* carbon uniting with an equal quantity of oxygen develops only 4296 units.

The difference, 5908 units, is expended in effecting the change of condition, and becomes latent, the latent heat of carbon being six times that of steam.

To raise one pound of carbon to 2250°, the specific heat of carbon being .2411, will require .2411 × 2250° = 540 units. One pound of carbon requires 1⅓ pounds oxygen, and 1⅓ pounds oxygen unite with .166 pound hydrogen, and the heat units developed in the combustion of one pound hydrogen, less the latent heat of steam, will be 53,800, available for calorific power.

1⅓ lbs. oxygen + .166 lb. hydrogen = 1.5 lbs. water.

To convert 1⅓ lbs. water into steam requires 1449 units.

To raise 1⅓ lbs. of steam to 2250° requires 1067 units, the specific heat of steam being .474.

The sum of these units, which expresses the calorific energy expended upon the material, not allowing for losses by radiation, is—

| | |
|---|---|
| Latent heat of carbon..... | 5908 units. |
| To raise 1 lb. of carbon to 2250°..... | 540 " |
| To convert 1⅓ lbs. of water into steam..... | 1249 " |
| To raise the steam to 2250°..... | 1067 " |
| Total calorific energy expended..... | 8974 " |

The hydrogen liberated is .166 lb., and the available units developed in its combustion, after allowance for latent heat, are 53,800 × .166 = 8932; so that the energy of reunion is, as was to have been expected, equal to the calorific power expended in dissociation.

But it must be observed that the hydrogen does not unite with the oxygen which it had given up to the carbon, but with a new equivalent of oxygen furnished without cost from the atmosphere, and the carbonic oxide takes another equivalent of oxygen from the atmosphere, and in burning to carbonic acid develops as many additional units as the hydrogen; so that the hydrogen and carbonic oxide from one pound of carbon in water gas would develop about 18,000 units, while under the most favorable circumstances, as in generating steam, solid coal does not generally furnish more than 9000 units per pound.

A simple illustration of the calorific power of water gas, as compared with the hydrogen and carbon of its constituents, can be given thus: 1 lb. of hydrogen unites with 8 lbs. of oxygen, forming 9 lbs. of water, and develops in combustion 62,200 units.

By contact with carbon at a proper temperature the 8 lbs. of oxygen unite with 6 lbs. of carbon, forming 14 lbs. of carbonic oxide, which develops 4443 units per pound, or a total of 62,200 units.

The water formula is $H_2O$ and carbon C. Dissociation produces $H_2$ and C.O. By taking oxygen from the atmosphere it becomes—

$H_2$+O, which develops 62,200 units,

and C.O.+O, which develops 62.200 units.

And the combustion of the two gases develops twice the 62,200 units of the original $H_2O$, or 124,400 units.

The carbon used in the production of the water gas was 6 lbs., and the maximum calorific energy of combustion of carbon theoretically would be 14,300 units per pound, or 85,800 units for 6 lbs., which is greatly below the 124,400 units theoretically developed in the combustion of the gases.

For all operations requiring high temperature, the differences are much greater in favor of water gas, both as regards quantity and intensity of calorific power utilized.

Dr. Prideaux has stated that at very high temperatures, as at the welding heat of iron, only one sixty-fourth of the theoretical calorific power of the coal is utilized.

These remarks are applicable only to a theoretically pure water gas composed of equal volumes hydrogen of and carbonic oxide. Such a gas cannot be produced practically in furnaces or cupolas, which is the ordinary mode of making water gas, and for two reasons, viz.:

1st. The introduction of air to secure the combustion of the coal necessary adulterates the gas with a large percentage of nitrogen.

2d. The direct contact of steam with the incandescent coal where there is no external application of heat, necessarily reduces the temperature and causes the formation of carbonic acid instead of carbonic oxide.

To correct an erroneous impression as to the temperature at which carbonic acid is formed, it is proper to state that vapor of water is dissociated by heat alone at a temperature of about 4500° Fahrenheit, and carbonic acid at a temperature of about one half, or 2200°. Consequently carbonic acid can not be formed, nor, if previously formed, can it continue to exist at this temperature. It follows, therefore, as a necessary consequence, from these positions, that a pure water gas, free from nitrogen and carbonic acid, can only be produced in close retorts, the temperature of which must be maintained with uniformity above 2000°, and this last condition requires that the gas itself, under constant volume and pressure, should be used as fuel, which is, moreover, the most economical arrangement possible.

Certain interesting facts in connection with the dissociation of aqueous vapor and the calorific power of carbon should be noted in this connection.

| | |
|---|---|
| The calorific power of carbon is given at..... | 14,500 units. |
| If to this be added the latent heat of carbon..... | 5,908 " |
| The sum is..... | 20,408 " |

which represents the total theoretical calorific power of solid carbon.

We have seen that 6 lbs. of carbon converted into water gas develops in combustion 124,400 units, which is 20,733 units per pound; so that by converting solid carbon into water gas the combustion develops the full theoretical power of the fuel, including the 6000 units rendered latent in effecting the change of condition from the solid to the gaseous state.

The elements of water are dissociated by heat alone at a temperature of about 4500°, but in the presence of carbon the dissociation is effected at one-half this temperature, and at about the same temperature carbonic acid is dissociated and cannot exist as such; so that the affinity of oxygen and carbon accomplished a result which, without the presence of carbon, would require 2200° of increased temperature.

In this connection a very interesting fact can be demonstrated, which is, that although in the presence of carbon the vapor of water is dissociated at a temperature only half as intense as is required by heat alone,

yet the calorific energy required to effect the separation is precisely the same in both cases.

*Dissociation of Vapor of Water.*

$H_2O$ is dissociated by heat alone at..... 4500° F.
In contact with C, at about half, or ..... 2500° F.

One pound of carbon requires 1⅓ lbs. of water to furnish oxygen for conversion to carbonic oxide. To raise 1⅓ lbs. of water from 60° to 4500° requires calorific units as follows:

| | |
|---|---|
| From 60° to 212°=152° : 152×1⅓=..... | 228 units. |
| There become latent in conversion of water into steam..... | 1449 " |
| From 212° to 4500°=4288° | |
| Specific heat of vapor, .474; and .474×4288×1⅓= | 3654 " |
| Heat units required to dissociate 1⅓ lbs. $H_2O$= | 5331 " |

In contact with carbon, 1⅓ lbs. water raised to 2250°, by calculation similar to the above, will be found to require 3126 units. And the pound of carbon will require to raise temperature to 2250° (the specific heat being .2411) 2250°×2411=..... 543 units.

| | |
|---|---|
| To convert 1 lb. solid carbon into gas (latent heat) | 5908 " |
| Add heat required to raise water to 2250°..... | 3126 " |
| | 9597 " |

But one pound of carbon, in uniting with 1⅓ lbs. of oxygen to form carbonic oxide, develops 4300 units, which must be placed to the credit of the account, leaving 5277, which is practically equal to the calorific power required to dissociated $H_2O$ by heat alone, with double the temperature as shown above.

*Comparison of Water Gas With Siemens' Gas.*

If the oxygen required for the conversion of carbon into carbonic oxide be derived from *air* instead of *water*, the results are widely different.

The carbonic oxide from the same weight of carbon will, of course, be equal in volume, and will possess the same calorific energy as in water gas, but instead of being re-inforced by the liberated hydrogen, which doubles its power, it is diluted and burdened by the released nitrogen, which robs it of a large proportion of its calorific power, as will be shown.

One pound of carbon unites with 1⅓ lbs. of oxygen, producing 2⅓ lbs. carbonic oxide, and develops in combustion 2⅓×4300=10,033 units. One and a third pounds of oxygen taken from the air liberates 1⅓×77÷23=4.5 pounds of nitrogen, nearly, and this nitrogen, adding to the weight of the products of combustion, diminishes largely both the intensity of combustion and the calorific power of the gas. But this statement is entirely too favorable, and does not fully exhibit the waste of energy from the production of Siemens' gas.

Siemens' gas is produced in furnaces to which air is admitted, and this air supplies the oxygen required for the production of the carbonic oxide. It necessarily follows that there is a loss of heat by escape through the flues of the furnace and by radiation, which has been estimated at from 25 to 50 per cent. If this loss be estimated at only 25 per cent. it will leave 75 per cent. of the fuel to be converted into gas.

In a report of Dr. Moore, dated January 22, 1878, the composition of Siemens' gas is given:

| | |
|---|---|
| Nitrogen..... | 0.7140 |
| Carbonic acid..... | 0.1053 |
| Carbonic oxide..... | 0.1752 |
| Hydrogen..... | 0.0055 |

Heat units utilized, 993 per pound.

From each pound of carbon deduct 25 per cent. loss; there will remain 75 per cent. converted into gas. The percentage of carbonic acid is .1053, and as each pound of carbonic acid contains 27 per cent. of carbon, the carbon rendered useless by conversion into carbonic oxide will be 1053×.27 =.0284. The carbon contained in the carbonic oxide is 43 per cent. Therefore, .1752×.43=.0753. The percentage of carbon lost by conversion into carbonic acid is .0284×100÷.1037=27, leaving 73 per cent. of gaseous carbon capable of being utilized.

If, then, 25 per cent. of the carbon in the furnace be lost through the chimney and by radiation, and 73 per cent. only of the remainder is capable of being utilized in gas, the proportion utilized in each pound will be .55. Seventeen and a half pounds of carbonic oxide in Siemens' gas carries with it 82½ lbs. of gases which are neither combustible nor supporters of combustion; therefore the .55 of a pound of carbon representing 1.28 lbs. carbonic oxide must carry with it 6 lbs. of useless gasses.

In the combustion of 1.28 lbs. of carbonic oxide .73 lbs. of oxygen are required; and assuming that no more air is supplied than the exact amount which will suffice to furnish the oxygen, the quantity of air will be .73×100÷23=3.17 lbs.

It appears, therefore, that 1 pound of carbon in a Siemens' furnace will furnish, after deducting losses, 1.28 pounds of carbonic oxide, carrying with it 6 pounds of nitrogen and carbonic acid, and requiring for combustion 3.17 pounds of air—making the total weight of the products of combustion 10.45 pounds.

If the carbonic oxide is to be used for heating other substances at a temperature of 2000°, the quantity of heat available for this purpose from 1 pound of coal can be determined as follows: 1 pound of coal yields, after deducting losses as above stated, 1.28 pounds carbonic oxide; 1.28 pounds carbonic oxide develops 1.28×4300=5504 units. The specific heat of the gases being .23 on an average, 10.45×.23×2000°=4807, leaving only the difference, or 697 units, available for doing work at the assumed temperature of 2000°.

Notwithstanding the fact that the theoretical calorific power of carbon is 14,300 units, and that only 697 units, or 5 per cent., would appear from these figures to be utilized at a temperature of 2000°, the use of this gas is known to be more economical than the direct use of solid coal in metallurgy, a fact which is due to the more advantageous application of gaseous fuel.

Compare these results with those produced from the combustion of an equal quantity, 1 pound, of carbon converted into water gas. One pound of carbon produces 2⅓ pounds of carbonic oxide and .166 of hydrogen.

The combustion of these gases requires 2.666 pounds of oxygen, furnished by 11⅓ pounds of air.

The products of combustion are—

| | | |
|---|---|---|
| 3.66 pounds of carbonic acid..... | specific heat, | .2479 |
| 1.5 pounds vapor of water..... | " | .4740 |
| 2.85 pounds nitrogen..... | " | .2440 |

To raise these products of combustion to a temperature of 2000° requires 7539 units. The units developed by the combustion of one pound of carbon in water gas is

| | |
|---|---|
| 2.33 pounds carbonic oxide × 4300..... | 10,033 |
| .166 pound hydrogen, less latent heat of steam..... | 9,000 |
| | 19,033 |
| Deduct 20 per cent. required for fuel..... | 3,800 |
| | 15,233 |
| Units required to raise temperature of products of combustion to 2000°..... | 7,539 |
| Leaves available for work above 2000°..... | 7,694 |

As the number of units of heat available for work with the Siemens' gas from one pound of carbon at the same temperature, 2000°, was 697, it appears that the surplus calorific power above 2000° derived from a given weight of carbon converted into pure water gas should be eleven times as great as that of an equal weight of coal in Siemens' gas. At higher temperatures, as at a welding heat, the differences will be still greater.

It is this surplus calorific power above 2000° that constitutes the chief efficacy of fuel where high heats are required, and while it is impossible to secure a high heat with a fuel of low power, it is always possible with a fuel of high power, by reducing quantity in proportion to work to be done, to obtain any desired temperature below the maximum, and without waste by dilution with incombustible gases.

*Comparative Intensities of Combustion.*

It is usual to estimate the intensity of combustion by dividing the number of heat units developed per pound of combustible by the total weight of the products of combustion multiplied by their specific heat; but Mr. J. P. Gill has shown that such computations are erroneous, except in cases where the fuel is burned without doing any work. Where work is done, as in heating other bodies, the temperature is reduced, as the divisor must be increased by adding the product of the weight of the body heated into its specific heat.

The intensity of combustion of coal, Siemens' gas and water gas will be compared in two ways; first, by assuming that the fuel is burned and no work done, and, second, that the work of one pound of combustible is to heat one pound of water or its equivalent, 9 pounds of iron, the specific heat of iron being one-ninth that of water, nearly.

It will also be assumad that solid carbon requires for complete combustion double the quantity of air necessary to furnish the oxygen for chemical combination, while gaseous fuel can be consumed with very little excess.

One pound of carbon requires 2⅔ pounds of oxygen, which are contained in 11.6 pounds of air without excess, or 23.2 pounds with allowance.

The specific heat of air is .2377, and .2377×23.2=5.52.

one pound of carbon develops 14,300 units,

Then $\frac{14300}{5.52}=2400°$ when doing no work,

and $\frac{14300}{1+5.52}=2190°$ when heating one pound of water.

ne pound of Siemens' gas, according to Prof. Moore, develops 996 units, consists of 18 per cent. carbonic oxide and 82 per cent. carbonic acid nitrogen. .18 carbonic oxide requires .18×4÷7=.1 pound of oxygen ained in .43 pounds of air.

he weight of the products of combustion will be 1.43 pounds, the aver- specific heat 23 and the product 1.43×.23=.329. The temperature of bustion heating one pound of water will be 996÷1+.329=749°, and emperature, if no work be done, 996÷329=3000°.

*Intensity of Combustion of Water Gas.*

ater gas contains by weight 6.66 per cent. of hydrogen and 93.3 cent. of carbonic oxide. One pound of hydrogen requires eight nds of oxygen; .0666 pound requires .5228 pound of oxygen. The ht of the resulting vapor is .6 pound, the specific heat .474, and the uct .6×.474=.2844.

ne pound of carbonic oxide requires for combustion 4÷7 of a pound of gen; .9304 pound requires .5334 pounds. The weight of the product be 1.4668 pounds. The specific heat of carbonic acid is .217, and 68×.217=.3183. The whole quantity of oxygen in combustion was 32 pounds, and the nitrogen mixed with it was 1.0662×77÷23=3.57 nds. The specific heat of nitrogen is .2438, and the product 3 57× 8=.87. The sum of these products, .2844+3183+.87=1.47.

he heat units developed in the combustion of one pound of pure water after deducting for the latent heat of the steam produced by the hydro- combustions, is 7645 units.

n, if one pound of gas is used to heat one pound of water, the tem- rature will be..... 7645÷(1+1.47)=3100°

And if no work is done..... 7645÷1.47=5200°

he comparative intensities of combustion, therefore, when one pound of bustible is employed to heat one pound of water or nine pounds of iron

| | |
|---|---|
| Coal | 2190° |
| Siemens' gas | 749° |
| Water gas | 3100° |

nd when burned without work the comparison stands—

| | |
|---|---|
| Coal | 2400° |
| Siemens' gas | 3000° |
| Water gas | 5200° |

is to be observed that there are no reliable instrumental means of tically determining very high temperatures, and all the theoretical putations are based on the hypothesis that the specific heat of bodies ains constant. It is an established fact, however, that specific heats are able, and the law of variation has been determined only within narrow ts and for a few substances. The specific heat of iron at 500° is differ- from its specific heat below 212°

recent paper submitted to the French Academy of Sciences by M. Violle es that the specific heat of iridium increases regularly with the tempera- , and gives 1950° C. of the air thermometer as the point of fusion. The ific heat of gold varies up to 600°, and then gradually increases toward point of fusion, 1035° C.

is probable that the increase of specific heat with increase of tempera- is general, if not universal, with all refractory bodies, and this fact is to impair confidence in the method of determining temperatures by ging a heated ball of platinum or other substance in water and noting rise of temperature which it causes. If the specific heat at high tem- tures is increased, the ordinary computation would give a result in ss of the true degree, as the specific heat is a factor in the divisor.

nother interesting comparison may be given. Siemens' gas develops available units per pound, and one pound of coal produces five pounds as; therefore,

1 lb. of carbon in Siemens' gas furnishes calorific power, 4980 units.
1 lb. " in coal utilized in evaporating water.... 9000 "
1 lb. " in water gas furnishes.....15233 "

r deducting the gas required for fuel.

he above calorific power can only be approximately utilized at low tem- ture, and as the temperature increases the differences are greatly more vor of the fuel of highest power.

must be observed, also, that it is only at very low temperatures that so e a portion of the calorific power of solid carbon as 9000 units can be ized. With exceptionally perfect apparatus and good firing it is claimed 12 pounds of water have been evaporated at 212° with one pound of combustible. This gives over 11,000 units out of a theoretical maximum of 14,300, but in metallurgy only a small percentage of this theoretical power can be utilized.

From notes taken of statements of prominent iron and steel manufacturers during a recent visit to Pittsburg, it appears—

Puddling requires one pound of fine coal to one pound of iron. To heat one pound of iron to 2700°F. requires 300 units. The proportion of calorific power of coal utilized is in this case 1 to 40, or 2½ per cent. Another manufacturer uses 40 bushels of coal to puddle one ton. The proportion here is 1 to 56, or less than 2 per cent. In heating iron for spike mill the proportion utilized was 1 to 30, or over 3 per cent. In blast furnace, heated to 3600°, the proportion was 1 to 45, or 2¼ per cent.

Natural gas is used at the Etna and Sligo works.

The president of the gas line states that 3500 cu. ft. of gas are equivalent to 35 bushels of coal.

| | | | |
|---|---|---|---|
| The calorific units in one cu. ft. of coal gas are..... | | | 557 |
| " " " | of water gas are..... | | 427 |
| " " " | of natural gas are..... | | 500 |
| " " | 35 bushels of coal..... | | 35,000,000 |
| " " | 3500 cu. ft. of natural gas..... | | 1,750,000 |

From which, if the statement be correct, it follows that a given amount of calorific power in the form of gas is twenty times as efficient in heating iron as an equal number of units in solid coal.

It is claimed that, notwithstanding the great waste in heating the nitrogen and carbonic acid of Siemens' gas, that its use saves two-thirds of the fuel as compared with coal in steel works.

It follows, from these facts and figures, that if water gas can be produced conveniently and cheaply it would be greatly superior to any other combustible, except, perhaps, natural gas, in all the essentials of quantity and intensity of heat and in economy of fuel. This result has been accomplished, and the plan for its utilization is of a very inexpensive character as compared with that which is in general use.

Water gas manufactured in cupolas and furnaces is now used successfully in Europe in metallurgy. The defects of this system have already been stated. It is simply impossible to obtain a uniform result with varying conditions; the furnaces must be heated by the admission of air, which introduces nitrogen, and unless the temperature is high, carbonic acid, instead of carbonic oxide, will be produced.

Carbonic acid, being dissociated at 2200°, cannot exist at or above that temperature; but when steam is admitted to a furnace it soon extinguishes the fire, and tests made in 1877 by Dr. Cresson, of Philadelphia, of numerous samples of so-called water gas, proved that there was no water gas in any of them, the heat of the furnace not having been sufficient to decompose steam. Gill's patents cover the only successful apparatus for producing water gas, by decomposing superheated steam in retorts from which air is excluded, and maintaining a uniform temperature around the retorts sufficient to prevent the formation of carbonic acid by using the water gas itself as a fuel.

The most perfect system possible would be to generate the gas in retorts, using the gas itself as fuel, and supplying the carbon in fluid or vapor. Where pipe lines to the seaboard furnish cheap petroleum for fuel, this system can be carried out in its perfection. With regular feed of steam and hydrocarban vapor, and uniform temperature from a gas fire, the production would be constant and the composition invariable. The labor of the retort house would be reduced to almost nothing; the feed, when once regulated, would require no changes, and no purification of the gas would be needed even for illuminating purposes.

*Water Gas from Petroleum, using Gas as a Fuel.*

Suppose crude petroleum be used instead of coal in the retorts, what will be the result as regards economy and character of the product?

Sixteen pounds carbon and 24 pounds of water produce 1000 cubic feet of water gas.

If carbon is furnished by petroleum, an additional quantity of hydrogen will be liberated.

The composition of light crude petroleum from Pennsylvania is—carbon, 82; hydrogen, 14.8; oxygen, 3.2.

The oxygen, 3.2, would neutralize 3.2÷9=0.36 of hydrogen, and leave 14.8—0.36=14.44 hydrogen.

The proportion of hydrogen with 16 pounds carbon is 82:16::4.44:2.82 and 2.82×190=536 cubic feet.

Sixteen pounds carbon and 24 pounds water give—

| | | |
|---|---|---|
| 37.34 lbs. carbonic oxide | 523 | cu. ft. |
| 2.66 lbs. hydrogen | 508 | " |
| Add 2.82 hydrogen | 536 | " |
| 42.82 | 1567 | " |

| | | | | | |
|---|---|---|---|---|---|
| Hydrogen by weight, 12.8 per cent ; carbonic oxide, | | | | 87.2 | per cent. |
| " | volume 66.6 | " | " | 33.3 | " |
| Cubic feet per pound | | | | 36.5 | |
| Specific gravity | | | | .364 | |

If 16 pounds of carbon are contained in 1567 cubic feet of gas, the quantity of carbon in 1000 cubic feet will be 10.2, and if 82 pounds carbon are contained in 100 pounds of petroleum, the quantity of petroleum to furnish 10.2 pounds or 1000 cubic feet of gas will be 12.4 pounds, and at 6½ pounds to the gallon this will be a little less than 2 gallons.

Oil at 2½ cents per gallon will be 105 cents per barrel, and with pipe lines for transportation this will be a fair price.

At this price the petroleum for 1000 cubic feet of gas will cost 9 cents, or, allowing for gas for fuel, 6½ cents.

The calorific power of this gas, allowing for latent heat of steam,

| | |
|---|---|
| .128 × 53,000 | 6,784 units. |
| 872.000 × 4,320 | 3,767 |
| | 10,551 |

Water gas from coal, at 4 cents per 1000 cubic feet, contains, after deducting for latent heat of steam, 7577 units, and in proportion to calorific power is equivalent to petroleum gas at 5½ cents, so that petroleum gas would appear to be ½ of a cent per 1000 feet more expensive, but considering the fact that petroleum can be fed continuously without opening the retorts, that the changes of temperature and production of carbonic acid can be avoided or greatly lessened, and the higher calorific power will also give higher intensity in doing work, the actual economy may be in favor of petroleum water gas at $1.05 per barrel, as compared with coal water gas a $3 per ton.

It has been seen that 12.4 pounds petroleum will produce 1000 cubic feet of gas. After allowing for the oxygen there will be 10.168 pounds carbon and 1.8 hydrogen, having a theoretical calorific power of 240,783 units. The 1000 cubic feet of gas, weighing 27.3 pounds, at 10,557 units to the pound, will develop 288,042 units, and additional calorific power having been contributed by the hydrogen of the decomposed steam.

*Intensity of Combustion of Petroleum Water Gas.*

It has been shown that one pound of gas contains .128 hydrogen and .872 carbonic oxide. .128 pound hydrogen requires .128 × 8 = 1.024 pounds oxygen, furnished by 1.024 × 100 ÷ 23—4.4 pounds of air, carrying 3.376 pounds nitrogen.

The products of this combustion are 1.152 pounds vapor of water, specific heat .474, and 3.376 pounds nitrogen, specific heat .244.

.872 pound carbonic oxide requires for combustion .872 × 4 ÷ 7 = .512 pound oxygen, contained in 2.2 pounds of air, carrying 1.688 pounds nitrogen.

The products of combustion multiplied by specific heats are—

| | |
|---|---|
| 1.152 pounds water vapor × .474 | .546 |
| 5.064 pounds nitrogen × .244 | 1.236 |
| 1.384 pounds carbonic acid × .2164 | .299 |
| 7.600 | 2.081 |

One pound of this gas develops 10,551 units, and if burned in just sufficient air to furnish oxygen, the temperature would be 10,551 ÷ 2.081 = 5070°.

If one pound of gas be required to heat one pound of water, or 9 pounds iron, the temperature would then be 10,551 ÷ 3.081 = 3420°.

*Water Gas from Naphtha.*

If naphtha be used instead of petroleum, the quantity of hydrogen will be further increased. The specific gravity of the gas will be reduced, and also the percentage of carbonic oxide.

If a spirit be used having a boiling point 126° F., composition $C_{11}H_{16}$ (old style), percentages 71.74 carbon and 28.26 hydrogen, the quantity of hydrogen combined with 16 pounds carbon and liberated in the formation of water gas would be 71.74 : 16 : : 28.26 : 6.2, and 6.2 × 190 = 1178 cubic feet.

The water gas formed from the sixteen pounds carbon is as previously found—

| | | |
|---|---|---|
| 37.34 pounds carbonic oxide | 524 | cubic feet. |
| 2.66 pounds hydrogen | 508 | " |
| 6.20 pounds hydrogen from naphtha | 1178 | " |
| 46.2 pounds gas | 2209 | " |

| | | | | |
|---|---|---|---|---|
| Proportion of hydrogen by weight, | 19.2, | carbonic oxide, | 80.8 | |
| " " by volume, | 76.3, | " " | 23.7 | |
| Cubic feet to one pound | | | 48.0 | |
| Specific gravity | | | .277 | |
| Calorific power per pound, less latent heat | | | 13,700 | units. |

*Water Gas by the Lowe, Strong, and other Furnace or Cupola Processes.*

It is impossible to give with any accuracy the composition of this gas, for the very obvious reason that it has no uniform composition. Where steam is admitted to a furnace containing heated coal, the effect is to reduce the temperature, and in a short time to extinguish combustion. In no two successive minutes can the product be the same.

Reference has already been made to the report of Dr. C. M. Cresson, of Philadelphia, who analyzed samples of water gas, so called, taken from the premises of consumers in Trenton, Manayunk. and Columbia, in which no water gas was found ; but Prof. Moore gives an analysis of a sample which, in the pamphlets issued by parties interested in the Lowe and Strong processes, may be considered a favorable presentation. This report gives the analysis as follows :

| | |
|---|---|
| Oxygen | .0174 |
| Carbonic acid | .0637 |
| Nitrogen | .0880 |
| Carbonic oxide | .7097 |
| Hydrogen | .0747 |
| Marsh gas | .0465 |

Eighty-two per cent. of these gases are combustible ; the balance, 18 per cent., are not only incapable of burning or of supporting combustion, but diminish the heating power of the combustible gases. The hydrogen is only 7½ per cent. by weight, while in the Gill gas, from naphtha, the proportion is 19.2 per cent.

Even with these drawbacks the Strong water gas is greatly superior in calorific power and intensity to the Siemens' gas, but the Gill water gas is superior to the Lowe and Strong, and costs only half as much when produced from anthracite coal, or coke, and water with the gas itself as fuel.

*Gill Hydrogen Gas.*

All gas produced either wholly or partially from the decomposition of water are called water gases, and when coal or coke are used to effect the decomposition, the resulting gas, if pure, consists of equal volumes of carbonic oxide and of hydrogen.

Where the carbon required to effect the decomposition of the water is supplied by naphtha or petroleum, the proportion of hydrogen is increased and the carbonic oxide is diminished.

Although an eminent chemist declared, in a report made in 1877, "*there is no known practical method of removing carbonic oxide from illuminating gas,*" J. P. Gill had, before this time, discovered and patented processes for removing the whole or any portion of the carbonic oxide, and of replacing it by an equal volume of hydrogen, so that the resulting gas could be absolutely or commercially pure hydrogen, or could contain such portion of hydrocarbon or carbonic oxide as would give a proper specific gravity for use for illuminating purposes, both specific gravity and candle power being controllable at pleasure. The additional cost of removing the carbonic oxide entirely is covered by about four cents per thousand cubic feet, but the entire removal for most purposes is neither necessary nor desirable.

## Gas and Gas Making.—II.

By L. P. Gratacap, Ph.B.

*The Process.*

The manufacture of gas involves two steps—first, the generation of the gas, and, second, its purification. And whereas the first depends largely upon the raw material worked, viz., the coal, both as to the properties and volume of the gas obtained, the second is under the manufacturer's control—is, indeed, the direct application of methods and apparatus to accomplish a known result, which is more or less perfect according to the adequacy of the means employed. Heat is the means employed to form and expel gas from coals, and cannel and caking bituminous coal forms the material usually expected to yield it. These minerals yield, upon the application of heat, a large volume of gas, tar, and ammoniacal liquors, which, separately collected, form three commercial products, variously related in quantity and quality, according to the conditions of heat under which they are made.

The familiar experiment of luting a perforated lid upon a small porcelain crucible, in which is placed a fragment of these coals, exposing the vessel to a naked flame, and lighting the current of volatile bodies which issues from the aperature, and becomes visible as a wisp of flame, exactly illustrates the process in use upon a practical scale in our gas houses. The small crucible is replaced by banks of clay and iron retorts, so built over and around a central fire as to receive its heat most advantageously ; the fragment of coal, by charges of 200 lbs. of coal ; the aperature, by ascension pipes, which conduct the gases from the mouths of the retorts up to one general receptacle, where the mixed products from the entire bank commingle ; the lid,

by an iron mouthpiece screwed tightly on by a threaded handle; and luted by lead films or a cement of mortar and fire clay; the naked flame, by a grate fire plied constantly with coke, and kept in such a vigorous combustion as to raise the heat of the retort up to 2200° F. These retorts, almost universally made of clay, are ⊐ shaped, are some seven feet long, and are arranged in tiers through the length of the retort house, inclosed in a wall of brick, surmounted by a line of pipes which connect with them and collect their individual yields of tar, gas, and ammonia water into the hydraulic main, the common reservoir into which all these conduits dip. Each set of five or seven retorts is heated by a single fire of coke, except where the Siemens regenerating furnace is used, whereby one centre of consumption may heat 128 retorts, provided its heat is distributed by means of regenerative chambers beneath each bench of eight retorts. As their contents become exhausted they are charged by the workmen with additional coal, by means of long, trough-shaped scoops of iron, which are filled with coal and thrust into them with remarkable dexterity and precision, then overturned and withdrawn, and the covers sealed on before the volumes of gas which burst out from the hissing piles are lost, either by escape or ignition. The discussion of the load of coal sealed up within this narrow chamber and dissolved by the power of heat into such various elements is of the greatest interest, and to the engineer in its practical, and to the chemist in its theoretical bearings, offers equal and paramount attractions.

We may reasonably expect to find in the gases evolved those very gases occluded in the coal as it lies in coal seams, which have been produced by a process of slow combustion or distillation, and which have been expelled from natural coals at a temperature of 100° C., by Mr. J. W. Thomas, upon their exhaustion in vacuo, viz., carbonic oxide, carbonic acid, marsh gas, ethane, quartane, oxygen and nitrogen. And, in reality, these are all present in the crude gas, except that the paraffine gases, ethane and quartane, are largely replaced by olefiant gas and olefines, upon whose illuminating power the gas-maker relies for the efficiency of his light, and which may be formed *de novo* in the process of distillation, or reformed by the decomposition of those higher, more complex hydrocarbons. Besides these there are, in fact, a number of other luminants of a high gravity formed in the distillation, diluents or non-luminous gases, and, as every element is set free, and in its escape forms those unions which its affinities prompt, a great number of impurities. In short, the original coal is broken up by the dissociating power of a high heat, which, besides effecting the mechanical liberation of its component atoms and molecular groups, imparts to these nascent bodies a chemical activity and sympathy which converts the retort into a laboratory, where an elaborate series of syntheses and reductions are taking place, with an intensity, rapidity, and complexity of which only the extraordinary lists of products obtained in the gas, ammonia water, and tar can suggest an adequate conception. Thus the constituents of the gas alone, and its impurities, as given by Dr. Chandler, make a formidable array:

*Luminants.*

| | | |
|---|---|---|
| Paraffines, | Acetylene, | Diphenyl, |
| Propyl, | Valylene (?) | Anthracene, |
| Alcohol radicals, | Benzole, | Pyrene, |
| Olefiant gas, | Toluol vapors, | Chrysene, |
| Propene, | Phenylene, | Phenol. |
| Butene, | Cinnamene, | |
| Olefines, | Naphthalene, | |

*Diluents.*

| | | |
|---|---|---|
| Hydrogen, | Marsh gas, | Carbonic oxide. |

*Impurities*

| | |
|---|---|
| Sulphureted hydrogen, | Ammonium sulphocyanide, |
| Ammonium sulphydrate, | Ammonium cyanide, |
| Bisulphide of carbon, | Ammonium mono-carbonate, |
| Oxysulphide of carbon, | Carbonic acid, |
| Sulphurous acid, | Nitrogen, |
| Mercaptan, | Oxygen, |
| Sulphur bases, | Water. |

The question instantly occurs, To what extent can the gas engineer modify the results obtained in the retort, and in what way? There can, of course, be no direct interference with the inevitable assortment of bodies produced by the distillation of coal; but that assortment can be quantitatively influenced by the engineer's control over the heat, the analytical agency which dissipates the atomic household known as coal, and permits the erratic affinities of its parts an undisturbed action. With a high heat he can produce more gas of a thinner character, and less illuminating power, but composed of more inflammable and higher heating gases, as hydrogen and marsh gas. The hydrocarbons which form the light-giving element of the gas are destroyed by simplification, *i. e.*, division, or their carbon lost by deposition in the form of graphite upon the sides of the retort or in the interstices of the residual coke. For the heavier bodies which would condense after sublimation are unable to withstand the molecular agitation produced by the high heats, and fall apart into simpler and gaseous forms, and thus the gas volume is increased by a redistillation of these tarry bodies, otherwise lost in the hydraulic main. With a low heat the oils increase and the gas diminishes, but this gas is of a high illuminating power, and heavy, the amount of heat requisite to convert the solid hydrocarbons into gas, or to break up into simpler bodies the rich and luminifeous gases and vapors, not being supplied. The contrasted effects of high and low heats are shown to an extreme degree in this table:

2240 lbs. of Newcastle coal yielded—

| 1. When distilled for gas at a high temperature. | | 2. When distilled for oil at a low temperature. | |
|---|---|---|---|
| Gas | 7450 cu. ft. | Gas | 1400 cu. ft. |
| Coal tar | 18½ gals. | Crude oil | 68 gals. |
| Coke | 1,200 lbs. | Coke | 1280 lbs. |

It is evident, then, that a gas engineer must avoid, if he wishes to make a gas commercially attractive, high heats, whereby the illuminating power of his flame is diminished, and its heat uselessly and uncomfortably increased; and equally shun low heats, whereby he generates a gas of a brillient quality, but industrially expensive from the small volumes obtained. There are other considerations which render this latter working objectionable, as condensation, smoky flames, etc., to be mentioned hereafter. The engineer is naturally desirous of seeing a good showing on his station meters, and recommending the management of his works by a large yield, and a promised proportionate increase of revenues to the company; but he must bear in mind the necessities of the consumers, and conciliate their tastes and wishes by a flame of beauty and brilliancy. It is sometimes difficult to neutralize these opposite tendencies by any satisfactory compromise. But he is assisted here by a proper use of his power to regulate the phases of distillation in the retort, in a second way, *i. e.*, lengthening or shortening the duration of the charge before the retort is emptied or refilled. A moment's view of the sequence of events in the retorts will explain the relative importance and meaning of these two methods. The charge of coal after inclosure in the retort becomes at first heated to the point of distillation only on its superficies, and heavy carbonaceous vapors pass upward against the heated arch of the retort, where they absorb the heat necessary to change them into permanent gases, and these primary gases formed from the richest distillate are of a high illuminating power, olefines, acetylenes, etc. As the upper coals become exhausted of their gaseous bodies, the surface becomes a red hot mass of coke, through which the vapors, oils, and gases from the interior must now pass, and in their transit become fixed. The tendency of this action is plain enough. The final products becoming exposed to greater heats as well as more extended surfaces already heated, are progressively decomposed from the heart of the charge outward, until reduced to thin heating gases, of little or no photogenic capacity, and there are produced, a short time after the charge is thoroughly heated somewhat beyond the temperature of distillation, poorer and poorer gases. In other words, a long time charge yields quantity rather than quality of gas, and, on the contrary, short time charges afford a better quality of gas with reduced production.

Dr. McAdam, of Edinburgh, has compiled the following table from his own experiments in this matter, wherein the first line opposite each coal represents the results of a long time charge, 4 hours, and the second line those of a short time charge, 3 hours, affording a very clear proof of the deterioration of the illuminating properties of the gas simultaneously with an increase of volume:

| | Yield of gas from one ton of coal. Cubic feet. | Illuminating power of 5 cu. ft. of gas in standard candles. |
|---|---|---|
| Heywood cannel | 11,153 | 30.97 |
| | 9,333 | 34.87 |
| | 1,820 | 3.90 |
| Bank gas coal, upper seam | 10,080 | 27.67 |
| | 8,516 | 31.45 |
| | 1,564 | 3.78 |
| Bank gas coal, upper and lower seam | 10,126 | 27.07 |
| | 8,468 | 31.28 |
| | 1,658 | 4.21 |
| Lochgelly parrot coal | 10,040 | 26.24 |
| | 8,460 | 29.82 |
| | 1,580 | 3.58 |
| Raith parrot coal | 9,630 | 25.61 |
| | 8,180 | 29.26 |
| | 1,450 | 3.65 |
| Average | 10,205 | 27.51 |
| | 8,591 | 31.33 |
| | 1,614 | 3.82 |

From this Dr. McAdam concludes that the legitimate purposes of gas manufacture are best observed by the short time charges applied to cheap coals, that the gases lost are valueless, and that the increased photogenic power and the pecuniary gains made by using cheaper coals more than compensate for the loss of gas in the long time charges. In fact, if the gas is not to be enriched by further additions of luminiferous oils, the practice best calculated to secure satisfactory results to both consumer and manufacturer is 3½ hour charges of 200 lbs., at a temperature of 2,200°F., or a heat approaching orange whiteness, using mixed caking coals and low cannels.

In still another way the engineer is permitted to influence the composition and character of his gas. By the use of mixed coals in the charges he can successfully correct the peculiarities of the separate products of one or other coals, assist their desirable, and regulate their objectionable features. Generally speaking, an inferior and superior coal are to be used together, the light giving properties of the richest gas being diluted and mechanically held in suspension in the thinner and poorer product, while the latter's more combustible gases provide the amount of heat needed to raise the hydrocarbon particles to incandescence in the flame. Dr. McAdam has subjected this hypothesis to practical demonstration, and established by his results the favorable and important changes secured :

| Cannels. | | Yield in cu. ft. | Candle power in standard candles. |
|---|---|---|---|
| Separately distilled | 1 | 9,768 | 27·07 |
| | 2 | 11,153 | 30·97 |
| Distilled together | 1 and 2, | 10,714 | 32·27 |
| Separately distilled | 1 | 9,434 | 26·81 |
| | 2 | 11,452 | 29·39 |
| | 3 | 10,552 | 37·16 |
| Distilled together | 1, 2, and 3, | 10,677 | 32·96 |
| Separately distilled | 1 | 11,789 | 30·60 |
| | 2 | 11,153 | 30·97 |
| | 3 | 9,434 | 26·81 |
| | 4 | 11,525 | 30·26 |
| Distilled together | 1, 2, 3 and 4, | 10,752 | 32·48 |

Thus, through the adroit commixture of his coals, having previously determined the assemblage and proportions of gases obtained by their separate distillation, and the character of their individual flames, the engineer prescribes with more or less certainty the style of gas he wishes to produce, and may even delicately vary its less obvious features, exercising a tolerably efficient control over the reactions within the retort itself.

It is impossible perhaps to overestimate the desirability of his understanding the constitution of the gases made from his different coals, nor too strongly to emphasize the necessity of his own patient study of the results. The chemical reactions of gases in a nascent state, the precise effect of different treatment as regards heat, pressure, etc., is an obscurely defined subject, and invites earnest and original investigation.

The gas and other products as they pass away from the retorts, rise up in the ascension pipes and down the dip pipes, and bubble through the seal of tar and water already collected in the long iron tube called the hydraulic main. From this point forward cooling ensues, accompanied by condensation of vapors, steam, etc., and the agglomeration and falling of the tar particles mechanically conveyed along in the hot rush of the gas from the retorts. The gas, loaded with impurities, diluted by vapors, steam, volatile salts, etc., is in no commercial state, and before it is salable must undergo the process of purification. Condensation is the first step in purification, naturally, may be said to be physical, and involves certain explicit and recognized laws, which practically are often ignored, and perhaps more frequently never known. Briefly stated, the facts observed by scientists concerning the condensation and deposition of gases and vapors are these : "In a mixture of several vapors derived from substances having no solvent action on each other, the vapors act towards each other as permanent gases. When the temperature of the mixed vapors is reduced, the vapor having the lowest tension is precipitated from the other as from a permanent gas ; a portion of the vapor having the lowest tension being held in diffusion by the vapors having the highest tension, till it reaches the point of condensation, when the whole is condensed together. 2. In a mixture of several vapors derived from substances which dissolve each other in all proportions when the temperature is reduced, a portion of the whole of the vapors is simultaneously condensed, the quantity of each being dependent on the difference in tension between the vapors and the relative proportions in which they are present. 3. A mixture of several vapors derived from substances which only partially dissolve each other, on being reduced in temperature, follows in part the laws previously given, dependent on the proportion of each vapor present." (Letter of William Young to London *Journal of Gas Lighting.*)

The application of these laws is obvious. In the mixture of crude vapors, gases, and steam to be condensed, the bodies which it is desirable to separate are solvents, in smaller or greater proportions—especially the heavier hydrocarbons—for those bodies which it is desirable to retain, and consequently should the volume of mixed products be suddenly cooled to a point below the tension of its most condensable elements, the precipitation of these latter would involve that of the lighter, more permanent and useful compounds which were dissolved in them.

These are removed, since by the effect of solution their freedom is impaired and their vapor tension lowered. Slow cooling, on the other hand, permits the disengagement of the lighter gases from the embrace of their heavier companions, whose solvent action is reduced thereby, allowing the volatile bodies to escape more readily and more completely. Literally, this implies frictional condensation, the purport of which in the more advanced methods of condensation is the use of heat, actually to maintain the gas at successively lower degrees of temperature, until the heavier bodies drop out, and the light gases become materially freed from their mechanical and chemical bondage amongst the former.

Condensers are iron pipes, upright or horizontal, small or large, cooled by water or air, arranged in compartments offering some 100 feet of surface to every 1,000 cubic feet of gas cooled per hour, and in communication with vaults or wells where the ammonia water and tar are collected. In the application of the principle elucidated above, a secondary and valuable result is secured, that of retaining hydrocarbons in the gas, which dissolve a body called naphthaline, which frequently solidifies out of the gas, and clogs mains and service pipes, but which disappears in the presence of an excess of these hydrocarbons. Another fact in this connection is that it includes the rubbing out of the gas the mechanically suspended particles of tar. These are hurried along in the current, and settle only at those points where a momentary resistance from pressure on a new surface, change of direction of flow, or retention before narrow aperatures allow them to separate, from the slackened force of the gaseous tide which carries them on. MM. Pelouze and Andouin have utilized this action in the construction of an apparatus which effects partial purification by the emission of the gas through narrow orifices, in jets which impinge upon metallic plates, where they deposit their tarry particles. The gas, now in a great measure freed from the tar, oils, etc., which were mingled with it, and cooled down to a temperature of 70° or 80° F., begins to assume a more usual appearance, and is in a condition to be chemically treated, which its original thickened and turbid condition forbade.

Three impurities yet remain in in it which the subsequent steps of purification are calculated to remove. These are carbonic acid, ammonia, and sulphuretted hydrogen, of which for the present it may be said that the two last are objectionable on sanitary grounds, and the former for its deleterious influence on the flame.

The ammonia exists in the gas in the form of a sulphide, a carbonate, a sulphohydrate, a cyanide, a sulphocyanide, and free or caustic ammonia, and their elimination depends upon the solubility of these bodies in water, the ammonia itself being soluble to the extent of 770 parts in 1 part of water. But we might infer from the presence of the carbonic acid, which actually exceeds the quantity of ammonia in the gas by almost four per cent., that from its chemical antagonism it would neutralize the alkali and remove it from the gas as an acid or neutral carbonate. Though in this sense the gas, as far as ammonia is concerned, appers to possess within itself the power of self-purification, it cannot, under the given conditions, be completely realized.

Carbonic acid, water, and ammonia will not unite below 136.4° F., or 58° C., and hence we find in the water from the condensers free ammonia, taken out of an atmosphere which is charged with four times the amount of carbonic acid requisite to form an acid salt, and eight times the amount needed for a neutral salt. As the gas cools these salts are formed, with a preponderance of the neutral carbonate, for as Berthelot has observed, the acid salt proves unstable, at the lowest temperature displaying a tendency to decompose. Similarly the ammonia and sulphuretted hydrogen refuse to combine at temperatures above 134.6° F., or 57° C., and the unions between them undergo partial or entire disassociation at high heats.

Therefore the gas next undergoes washing or scrubbing, virtually identical operations, the theory of which is that the gas in a finely divided state should pass in an opposite direction to a shower of minute particles of water, and in this way, interpenetrated by the spray of the latter, surrender its ammonia. The process of washing or scrubbing is practically more than this: it corrects the inefficient working of the condenser, cools the gas still more, and decreases carbonic acid and sulphuretted hydrogen. It is impossible to overestimate the necessity of breaking up the water and gas in as perfect a way as possible if this washing is to be final, and every device has apparently been exhausted to effect this multiplication of the points of contact between the gas and the water. The disposition usually adopted is to make the gas rise up through a pile of coke, rubble, brush, lattice work,

and other devices for splitting, and, as it were, pulverizing the gas, through which from above shower of water is constantly passing, seizing wherever exposed to mutual contact the minute atoms of all soluble impurities.

Another consideration which renders this division imperative is the fact that its thoroughness enables an engineer to use less water and to diminish the time or space—the same thing—through which the gas is exposed to washing, and thus conserve in the gas those illuminants which water will inevitably filch from it, if too abundantly provided with good opportunities to commit the theft.

The best effects, especially as relates to the carbonic acid, are gained by cooling the gas sufficiently before its entrance to this water bath, and in summer, owing to the difficulty of effecting this thoroughly, carbonic acid passes through the scrubber but slightly diminished in volume. The ammoniacal water once used can be pumped over again with excellent results, as a sort of agglutinative affinity is set up between the ammonia atoms, and the caustic ammonia attacks and removes sulphuretted hydrogen.

In the perfect theory of gas making the prolongation of the action of condensation beyond the condensers should be made as unimportant as possible, as the water acts with more certainty, effectiveness, and economy in removing the ammonia the cleaner and lighter the gas is.

The movement forward of the gas through the condensers and scrubbers demands an increasing pressure, and the gas would be retarded altogether, partially, or these alternately, unless helped through by the engineer, who practically moves this pressure by sucking the gas out from the scrubbers by means of the exhauster—machinery which pumps litterally the gas from the scrubbers and condensers, enabling it to pass instantaneously upon its formation from the retorts. Thus the gas is secured as it is made, and removed from the heat of the retort, which would simplify its composition by breaking up the luminiferous hydrocarbons, whose rejected carbon would deposit on the sides of the retort, rendering it less pervious to heat, less capacious, and impoverishing the gas in the same proportion as well.

From the exhaust the gas meets the purifiers, and the engineer encounters the varied and difficult problem of removing the sulphur and carbonic acid.—*Scientific American Supplement.*

[To be concluded.]

## Can Gasholders be Dispensed With?

By James Alexander.

The statement that the world we live in is one of change, is constantly being forced on our notice, and is daily verified in our own experience. Nor is this changefulness without some valuable and permanent results. Some step hitherto unattained is reached, some new idea developed, some new invention or appliance brought forward, either to facilitate or improve formerly laborious or complicated methods of production. Almost in every branch of human skill or industry the word progress is deeply stamped, so that our favorite notions of some thirty or forty bye-gone years have to give place to improvements of more recent date. But while this progress goes on it must be admitted that novelty in any department is not necessarily an improvement, and it is only those inventions sound in principle, and capable of standing the test of thorough, practical experience, which can endure and become permanently useful, whilst those not possessing these qualities fall into disuse and sink into oblivion.

In no department of scientific or mechanical pursuits is the truth of these statements more clearly exemplified than in the various apparatus usually employed for the manufacture, purification, and distribution of gas. Time would fail to enumerate or even slightly touch upon a tithe of the inventions which have been before the public during the past twenty years, extending as they do to every portion of what is called gas plant, from furnace bars, retort lids, ascension pipes, hydraulic mains, on through every department of the condensing, purifying, and distributing process to the meter fixed in the consumer's house.

While not a little material advantage has been gained by the adoption of some of these inventions, a great many have passed away, when their day of advertising was done, having been weighed in the balance of practical utility and found wanting, and leaving no trace of their short lived existence, save that of producing by their failure a kind of conservatism among those connected with gas matters, as also a tendency to receive or adopt with a certain amount of caution, if not distrust, all new inventions. Secured as many of them have been by patents, and professing to effect a great saving in materials used for gas manufacture, as well as a great increase in illuminating power, one cannot well help thinking that some of these inventors it might, with propriety, be said—

> Each man thought full well
> Himself a heaven-sent engineer,
> A Stephenson or Brunel.

Novel and startling as some of these innovations alluded to have seemed, they fall short of the innovation involved in the question "Can Gasholders be dispensed with?" a question which well nigh met with ridicule from many members of a scientific body in Scotland to whom it was propounded some three years ago, and which elicited but a small amount of consideration. Perhaps the question led some of them to think that more serious and sweeping changes might be in contemplation, and the inquiry be made, "May not gas managers be done without?"—a much-to-be-dreaded consummation, for by this craft they have their living.

If gasholders can be dispensed with, it must be obvious to anyone, even but partially conversant with the working details of gas manufacture, that some equally ample and efficient means of storing the gas produced must be substituted, more especially in a country like ours, where the ever-changing length of day and night causes an equally varying demand for the means of artificial lighting. Were it even within the range of possibility—which it manifestly is not—by any arrangement to adjust the yield of gas to the nightly demand, the gas supplied to consumers would be alike uncertain in pressure, as unequal in illuminating power, and on this account the manufacture of gas would practically come to an end. It may not be out of place here to remark in passing that the want of some method of storage seems to be the great drawback to the practical adoption of electricity for lighting purposes. Could this be found and properly applied, combined with thorough subdivision, those engaged in the gas trade might have good ground for apprehension, but until these two important points are gained they need have no cause of alarm.

It has been suggested that large cylinders, with well-fitting, gas-tight pistons, might be employed for storage, the gas being by mechanical agency impelled into those in a highly compressed state, and from thence admitted into the mains at a proper pressure. To this, however, there is the objection that these would only be so many gasholders, diminished in size it is true, but still occupying much valuable space.

A large underground main, laid down alongside of existing mains, seems a more feasible plan, and, to prevent any misunderstanding in what follows, let the former be termed the stock and the latter the supply main. Branch connections should be made between the stock and supply mains, to be placed at regular distances and increased in size according to their distance from the works, so as to insure a larger flow of the compressed gas at the more remote parts of the mains. This arrangement is rendered necessary from the fact that, under the present system of gas distribution, a difficulty is felt in equalising the supply in districts lying at a considerable distance from the gasholders, for as cities or towns extend in any direction, and a consequent extension of mains becomes necessary, it is found that the increased consumption is not in proportion to the number of lights required in the new district, but that a certain amount of supply is withdrawn from former consumers to meet the requirements of the new ones.

The extent of stock mains required to store a given quantity of highly compressed gas will not be so great as at first sight might appear necessary. For example, one yard of a main, three feet in diameter, contains at ordinary pressure, 21 cubic feet of gas. Suppose that into the same space 100 additional cubic feet could by compression be stored, a main 5,000 yards in length would contain 500,000 feet for delivery into the supply mains through properly constructed self-acting governors, placed on the branches above referred to, thus giving the latter quantity for consumption before the equilibrium of the mains was restored to the normal pressure. If gas can be compressed to a point beyond what has been already indicated, the storage capacity of the mains will be proportionately increased. This, of course, must be tested by practical experiment, before a limit can be set with certainty to the compressibility of gas. If what now-a-days in advertisements is predicated of gas engines be according to fact, viz., that 24 hours supply for one of these to be employed for propelling tramway cars can be stored in a very small compass, it is not unreasonable to suppose that a large amount might be likewise stored for illuminating purposes in a very limited space. It is exceedingly doubtful if the necessary compression could be obtained by the employment of the rotatory exhausters now in use, as by them—even if sufficiently powerful to give the needed pressure—a pulsatory motion would be imparted to the gas in the stock mains, and from them, despite the governors, communicated to the supply mains, causing unsteadiness of the lights. Recourse would, therefore, have to be had to pumps constructed similarly to an air pump, but, having three cylinders in a line, the three pistons of which to be actuated by ordinary cranks, placed equally at three different points of the diameter of the driving shaft. It will be necessary to have these cylinders placed under water to prevent their being unduly heated, a result naturally to be looked for where great compression is found necessary.

An increased amount of leakage will be urged as an objection against this new method of storage, which doubtless will take place unless greater care is taken in jointing the mains than is usually bestowed on such work, which at ordinary pressure are frequently found very defective. If greater care in jointing fails to secure tightness flanged pipes may be used, where there is no risk of fracture to the flanges by the subsidence of the soil. When

there is any danger of such occurring, malleable iron pipes might be used with advantage.

Practical experience will soon meet and overcome such difficulties. If pipes can be and are jointed capable of resisting steam at high pressure, what is there to prevent similar tightness being effected in jointing pipes used for conveying gas.

Great expense will be brought forward as another objection, and doubtless, in existing works with ample holder accommodation, the expense might to some extent interfere with its adoption, but in the construction of new works, where the ground required for large gasholder tanks has to be obtained at great expense, and, taking into consideration the cost of constructing such tanks, with their holders and necessary gearing, and comparing this with the expense of laying down a main of equal capacity, the difference will not, we assume, be found so material as may be expected.

On a subject so new and untried we have to depend primarily on theory, until step by step we attain the practical. If, however, a saving in the cost of ground and construction be effected, coupled with a more equal distribution of gas, by the adoption of this method of storage, much will be gained and another advance made in the improvement of gas work plant.—*Review of Gas and Water Engineering.*

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[From London "Journal of Gas Lighting."]

## West of Scotland Association of Gas Managers

(Continued from page 60.)

Mr. Niven (Dunoon) said there was no doubt of this, that if "seeing is believing," as Mr. Peebles said, he had contradicted the proverb, because seeing his experiment was not believing that the burners were all the same size. Mr. Peebles proved by acts that seeing was not believing. Independent of that, however, if one looked to the small and the large burner, he would not say they were passing the same amount of gas; but he supposed they would burn the same amount of gas whether it were 5, 4, or 3 feet per hour.

Mr. Peebles—If they are adjusted to do so.

Mr. Niven from that inferred that if he wished a low pressure at his works, the better way would be to have the consumers provided with large-sized burners; but supposing the pressure in one place was 3-10ths and in another 17-10ths, he asked could he advocate larger burners in those districts of the town where there was the low pressure, and would the needle governor burners bring out the value of the gas in other parts where there was higher pressure?

Decidedly.

Mr. Niven said he was exceedingly well pleased with what he had seen, and also with the philosopher spirit with which Mr. Peebles carried out a practical matter. He gave the reason why, and that constituted the philosophic spirit.

Mr. Peebles said that when people wished to economize they rushed to small burners, thinking that if they kept down the size of the flame, they would also keep down the gas account. Instead of doing that, if they were wise, they would adopt large burners, and reduce the pressure. His arrangement of burners proved this point most conclusively. It was an apparatus that every gas manager ought to have beside him. It was not an expensive thing, and when he stated that "seeing is believing," he meant that there must be some indisputable practical basis for a standpoint to begin from. This must be proved by burning 5 cubic feet through each of the burners, testing their correctness as to the rate by an experimenting meter, and when satisfied that they were each burning 5 cubic feet per hour, the size of the flame must be observed, as had been done that day. "Seeing is believing" then became a truism.

Mr. Niven asked if there was any peculiarity in the burners.

Mr. Peebles replied that there was not; they were union jets. For English gas the batswing was the preferable burner, but for Scotch gas the union jet was undoubtedly the best.

Mr. Drysdale (a Director of the Bridge of Allan Gas Company) said he knew something about magic lanterns, and found that when gas was used without any cover he obtained a small light; but if the flame was enclosed in a glass shade, and a small aperture left for the atmospheric air to reach the burner, the light was more than as strong again. He asked whether the enclosed light did not burn air along with the gas.

Mr. Peebles said he did not know the arrangement Mr. Drysdale had for his magic lantern, but from his statement he should say that without the glass shade he mentioned, the flame was submitted to the action of a current of air, which produced the same effect as in many of the forms of gas globes having small holes at top and bottom. Such an arrangement formed a kind of chimney, and the induced current acting in conjunction with the pressure at which the gas issued, brought about the same phenomenon as was seen in the behavior of the fourth or high-pressure burner exhibited. When the glass shade was put over the light, leaving a small aperture for the admission of atmospheric air, the draught was stopped, which was equivalent to lowering the pressure. Carbon was disengaged as before, and the necessary quantity of oxygen being allowed for perfect combustion, a high temperature was obtained, and the gas was thus consumed under the most favorable conditions for developing its full illuminating power.

Mr. Adamson asked what was the practical test in illuminating power.

Mr. Peebles said the experiments were based on, and intended to verify and show practically the tabulated results of many experiments made by Mr. Stewart, of Greenock; Dr. Macadam, of Edinburgh; Dr. Wallace, of Glasgow; and Mr. Mitchell, of Dundee; which were given in a paper he read before the Royal Scottish Society of Arts, where it was shown that an increase of only 5-10ths pressure decreased the illuminating power about 18 per cent., an increase of 8-10ths about 30 per cent., and an increase of 14-10ths decreased the illuminating power more than 50 per cent.

The President said he should like to hear the opinion of any member as to the district governor prescribed by Mr. Peebles. He himself thought it was most important that gas managers should be in possession of a reliable instrument in the shape of a district governor. In some towns where the altitudes varied, these governors would be much to the benefit of the company, and would prove a blessing to the manager.

Mr. Mayer (Glasgow) said that when this subject was brought before the meeting of the North British Association at Edinburgh, a lively and exceedingly interesting discussion resulted. One point was with reference to the amount of unconsumed carbon given off by the smaller and larger flames. Mr. Peebles stated that he would make some experiments to test the question. His (Mr. Mayer's) opinion was that the smaller flame gave off, unconsumed, a great deal of the carbon of the gas, and if a marble slab were put over it, there would be carbon particles deposited more abundantly than from the others. He believed that the large burner was giving off much less unconsumed carbon, and therefore there was a greater amount of luminosity, the low initial pressure effecting more perfect combustion.

Mr. Niven thought the marble slab would not be a good test, because it would, to a certain extent, cool the flame, and carbon in the form of soot would then appear. Supposing there were different forms of combustion, and that in the case of the larger flame the carbon was brought into the solid form, and that was the basis of the increased luminosity, and if in the smaller flame the carbon assumed more the form of a vapor, and therefore decreased the luminosity, then he did not see how the marble slab could be a sufficient test.

Mr. Peebles said he thought Mr. Meyer was laboring under a wrong impression regarding the deposition of carbon that would take place by holding a marble slab over the different flames. He believed—indeed, he was certain, though he had not actually tried it—that the large flame would deposit carbon more freely than the smaller one, if submitted to the test suggested by Mr. Mayer, simple because it was nearer the smoking-point; and this might be made clear if it was considered what took place when using the ordinary gas blow pipe employed in brazing operations. It consisted of two tubes, one within the other, through which a supply of gas or air could be sent independently of each other, and by stop cocks could be mixed in any proportion wished for. If the gas alone were turned on, a long loose smoky flame was the result, which gave off a large amount of unconsumed carbon. If air were turned on very gently, the flame became shorter, more compact and firm, while the smoke entirely disappeared: and if the supply of air were still increased, the flame would go through all the phases of combustion, from the smoky, torch-like flame to the beautifully developed blue cone of the Bunsen burner. It was the pressure at the burning point which if unduly increased, took away the illuminating power also.

The President said that three winters previously some of the shopkeepers in Coatbridge asked him if it was possible to have their windows better lighted. There had been a good number of burners used, and the ceilings had been blackened. As a panacea for this evil, he applied to Mr. Peebles for some of his house governors, and put them on. Since then he had not had a single complaint as to the quality of the gas for illuminating purposes, nor of the ceilings having become black, which proved that non-scientific combustion of gas not only vitiated the air, but destroyed the furniture and paper in a room. When gas was burned at proper pressure there was no deposit of carbon.

Mr. M'Gilchrist said that the gas world and all the gas-consuming public were much indebted to Mr. Peebles for what he had done in connection with the combustion of gas; and if he was not by the present generation awarded the amount of consideration to which he was entitled, the succeeding generation would look back upon him as one of the pioneers in the field of discovery of how properly to burn coal gas. He moved—

"That the Association accords its heartiest thanks to Mr. Peebles for the way in which he responds to the request to read occasional papers."

The President, in reference to the district governor, said he wished to make a remark. He had one of Mr. Peebles station governors at his works.

One portion of the district he had to deal with was low-lying, some 200 feet below the level of Coatbridge, and 2½ miles away. He was much puzzled as to the way in which he was to give the initial pressure at that part of the district, and to keep up the supply; so he asked Mr. Peebles to consider the matter—to regulate the pressure in the main street at Coatbridge so as to throw back the pressure on the low-lying district. After a time he obtained from Mr. Peebles a 9-inch district governor, and he was happy to say it had given excellent results. There was an initial pressure of three inches at the works. This pressure was checked in the main street at a point leading to a higher level where the pressure was reduced, and this allowed the initial pressure to flow in the direction of the low-lying district. He had found the governor very reliable. In many cases it would also become a matter of great importance to reduce leakage by fixing these governors where there was an accession of pressure.

Mr. Peebles said—It only remains for me to thank you for your kind expressions in connection with the subject I have brought before you. It is always a great pleasure to me to come and meet so many friends, and ventilate those matters to which I have given some attention. I think it is a necessity now-a-days that engineers, without becoming what may be termed specialists, should devote themselves steadily to some particular branch of their profession. The subject of pressure, and the instruments for controlling, it, have engaged my attention for a good number of years; and I feel what Mr. M'Gilchrist stated to be quite true—viz., that the method of properly regulating and consuming gas is only developing itself. The expressions of approval I have had from so many of you to-day are an ample reward, I can assure you, for the little I have been able to do in connection with this subject.

[From the "Sanitary Engineer," Feb. 1.]

## The Expenses of Gas Making.

Consolidation has completely failed in Brooklyn, so that we are deprived of the chance of studying the problem of the day in an attempt at solving it. In this city the companies are cutting each other's throats, or each other's prices, it does not matter which, but in a business way a screw is loss somewhere. The competition in New York has driven prices down to a non-paying rates. As things now stand, dividends are a thing of the past; when they will be a thing of the present, none can tell. None of the companies can be said to be really doing a paying business, and profits, if any, are very small. Capital is not subscribed for this sort of work, but the public seem unwilling to look on gas affairs from a business point of view. It is always the cry of monopoly that is raised. The public cannot realize the fact that very large expenses have to be met that are not chargeable to the manufacture of gas at all, such as interest, depreciation of plant and cost of maintenance. Men have to be employed to put in and take out meters, to take the meter registers, collect bills, etc., besides the clerks and bookkeepers and other officers. These expenses all tell, and make gas much more expensive than many imagine. It is so simple to say that a ton of coal costs five dollars and makes ten thousand feet of gas, that the residuals pay for the labor, and that therefore gas only costs the company fifty cents a thousand; but it is all wrong. Ten per cent. or more of the gas made is lost by leakage, and any company that can pay for their labor by their residuals is most fortunate, for it can be hardly done in this country. The manufacturing of gas is only one item of the cost of making it, the taxes, office expense, expenses of distribution and leakage, and in some cases interest on bonds, make up the others. So many items of expense entering into it make the reliable determination of the cost of gas to the company a matter of careful bookkeeping and calculation. The question of what gas costs any company is one of much complexity to those most intimate with its business, and the fact of its being such, proves the folly of outsiders in trying by hasty methods to prove that gas can be sold at a profit for fifty cents a thousand.

We have enlarged above on the fact that a great part of the expenses of supplying gas is quite independent of its manufacture. After it is in the holders, a great proportion of the expense has still to be incurred in distributing it, paying taxes, etc. Here is an important fact bearing on the question of the electric light. The assertion is made, that by the latter, so many candles' light can be produced for so much money, perhaps half or a quarter of the equivalent of gas at two dollars and a half. Suppose the light *can* be produced in a laboratory at those prices; there are in practice still the expenses of distribution, office expenses, and taxes to be paid, and these figures are completely ignored in all calculations of the cost of the electric light. Mr. Edison proposes to establish stations all over the city, each station supplying perhaps the houses within half or a quarter of a mile. Throwing aside all considerations of coal burnt and engineers' wages let it be considered what the other expenses will be; the lamps will require a certain amount of inspection, the line wire will have to be kept in order, the taking the register of the Edison electric meter (which involves the removal and delicate weighing of a film of copper), the proper superintendence of so many stations, and a host of other items, will involve a vast expense, probably much greater than the corresponding expenses of distribution that have to be sustained by an ordinary gas company. Electric apparatus require very careful watching and attention, at least they have always required it. This very watching and attention costs money, and will run up the expenses of the electric light to a very high figure. The more work can be centralized, the cheaper is it done, but electricity starts out by opposing centralization.

The financial term corresponding to centralization is the familiar word "consolidation." Most gas financiers seem to recognize in it the remedy for New York's troubles, and for the coming trouble of Brooklyn. For this reason we are sorry that it could not have been experimented with in the smaller sister city as a guide to the larger. Most of the Brooklyn companies have their stock so low that it is not likely consolidation would have injured it any, whether it did good or not. The public judgment in the matter can only be judged of by the stock quotations. Brooklyn gas stocks advanced as consolidation seemed certain, and as suddenly fell when consolidation failed. But whatever our private opinion may be, this is, of course, only a place for discussion, and most schemes of consolidation, involving delicate valuations of stock of the different companies entering, have two sides of the question, an affirmative one and a negative one.

We think we have said enough to show the folly of those ignorant of the nature of the business attempting to dictate to the companies what the price of gas should be. Very few, even among those directly interested in the business, know just what gas when paid for has cost. In the papers of several of the Western cities that want gas at a nominal sum, it is really amusing to see the learned editorial calculations of the cost of gas, and the attempts to show that some ridiculously small price should pay a ten per cent. dividend. However, the gas business with all its complexity is the one that everyone knows more about than his neighbor, or, at any rate, is the one in which those who know nothing about it think they can name the proper price.

## Extract from a Review of the Thermic Motors Exhibited in Paris, in 1878.

By V. Dwelshauvers-Dery.

[Translated from "Revue Industrielle des Mines," for "Van Nostrand's Magazine."]

* * * * * As we are to present calculations upon gas engines, we will first seek to determine the least expense that we can hope for in these motors. Then we can judge more easily of the extent of the possible improvements.

It is not easy to get exact statements in regard to the composition of illuminating gas. Its density also depends upon conditions that we do not pretend to consider here. We take such figures as seem to represent a medium composition and heat.

| | |
|---|---|
| Carbon | 0*k*.605 |
| Hydrogen | 0 .212 |
| Oxygen | 0 .077 |
| Nitrogen | 0 .106 |
| | 1*k*.000 |

The weight of a cubic meter at a mean temperatnre and pressure is 0*k*·585, the same solume of air weighing 1*k*.3

To determine the calorific power, we deduct from the amount of hydrogen 0*k*.0096, one eighth of the weight of oxygen, as being already combined with oxygen. We have then for the hydrogen available for fuel, 0*k*.2024. Multiplying the carbon and hydrogen by their respective calorific powers, we get—

| | |
|---|---|
| 0*k*.2024 × 34460 | = 6975 calories. |
| 0*k*.605 × 8060 | = 4876 " |
| Total.... | = 11851 " |

To determine the quantity of air required, we proceed as in the case of coal.

| | | |
|---|---|---|
| For Carbon | 8÷3×0.605 | = 1*k*.613 oxygen. |
| For Hydrogen | 8 ×0.2024 | = 1 .619 " |
| Total | | = 3 .232 |

The air required being 4¼ times this, we have: 14*k*.546 of air for each kilogram of gas.

The products of combustion are—

| | | |
|---|---|---|
| Carbonic dioxide | 0.605+1.613 | = 2*k*.218 |
| Vapor of water | 0.202+1.619 | = 1 .822 |
| Nitrogen originally | 0·106 | 11 .420 |
| " with the air | 11·314 | |

If the heat of the combustion were entirely employed in augmenting the temperature of the products, this rise of temperature could be deduced by employing the specific heats of the substances as follows:

| | | |
|---|---|---|
| Carbonic dioxide | $2k.218 \times 0.217$ | $=0.4813$ cal. |
| Steam | $1 .822 \times 0.475$ | $=0.8655$ " |
| Nitrogen | $11 .420 \times 0.245$ | $=2.7979$ " |
| Total | | 4.1447 |

The augmentation of the temperature is therefore—

$$\frac{11851}{4.1447} = 2859°.$$

Such a temperature being too intense, it is necessary to diminish it. The reduction in the Otto gas engine is brought about by the admission of a liberal supply of inert gas to mix with the combustible. In this engine, which renders good practical results, there are added to 15k.546 of the products of combustion, 10k.793 of the same composition. Consequently there is a total of 26k.339 of gaseous products, which require

$$4.1447 \times \frac{26.339}{15.546} = 7.0222 \text{ calories}$$

to raise the temperature one degree.

Then the rise of the temperature in the Otto engine with constant pressure would be—

$$\frac{11851}{7.0222} = 1688°$$

In this engine it is not probable that this temperature is attained, because a part of the heat is absorbed by the work during the combustion. Another portion is absorbed without useful effect by the cold water employed about the moving parts to prevent overheating.

But to determine the efficiency of this motor, we must compare it with an ideal engine, which, expending 11851 calories, experiences a fall of temperature of 1688°.

For this purpose we will suppose that the temperature of the cold body, the outside air is at 0°, or 273° above the absolute zero.

A perfect thermic motor would afford in work

$$425 \text{ k m} \times 11851 \times \frac{1688}{1688+273} = 4{,}335{,}570 \text{ kilogrammeters for each kilogram of gas burned.}$$

It follows that a cubic meter of gas would afford

$$4335570 \times 0k.585 = 2{,}536{,}308 \text{ k.m.}$$

The Otto engine consumes about a cubic meter of gas for a performance of one horse power per hour; that is, it yields 270,000 kilogrammeters of work for a cubic meter of gas.

Its efficiency then is—

$$\frac{270000}{2536308} = 10.64 \text{ per cent.}$$

This is the result as measured by the friction-brake; but if we measure by the indicator, as is done in steam engines, the result is considerably modified.

The consumption for each indicated horse-power per hour is only two-thirds of a cubic meter of gas. That is to say, the Otto engine measured by the indicator exhibits a performance of—

$$3 \div 2 \times 10.64 = 15.96 :$$

nearly 16 per cent., which is about double the efficiency of the steam engine.

If we do not regard the price of the fuel, the gas engine is superior, in point of efficiency, to the steam engine.

Much remains to be done in improving the gas engine. But the margin for improvement is less than in the steam engine, or than in any motor employing a fluid heated through an envelope, by gaseous products of combustion.

The principal cause of loss in the Otto engine exists in the high temperature at which the gas is released after its expansion in the cylinder. We have been able to verify the statement that the gases at their exit have nearly 900° of heat. Now if we could expand them to zero, utilizing the heat in external work, we should regain forty-five per cent. Evidently this is practically impossible. But in the steam engine, besides the *practical* impossibility of realizing twenty-three per cent., there is the *theoretical* impossibility of ever passing this limit by reason of the mode of employing the heat.

The gas engine in the most perfect form known to-day, is susceptible of great improvement, incomparably greater than can possibly be made upon the steam engine.

---

Cement for Attaching Leather to Metal.—Wash the metal with hot gelatine; steep the leather in an infusion of nut galls (hot) and bring the two together.

## The Electric Light.

### Mr. Edison's Lamps Breaking.

Facts recently published in regard to affairs at Menlo Park show that the electric light, as at present constituted, has proved a failure. Several of the glass globes have been cracked by the expansion of the platinum wire, the air has been thus admitted and the carbon, of course, instantly consumed. What has happened to one lamp at any moment may happen to another, or to all. The breakages already recorded are sufficient to upset the claim to the stability that is so absolutely essential to success. It should be noted that precisely the catastrophe that has occurred was prophesied by scientists when Mr. Edison first explained his scheme, the prophecy being based upon the known inequality in expansion when heated of platinum and glass. With that cheerful perseverance which is so pleasingly characteristic of the inventor, he now is a work inventing a sort of glass that will expand equally with platinum; or will do something else equally original and unglasslike calculated to adapt it to his needs. We are not prepared to say, such is Mr. Edison's luck—we cannot give it a more imposing title—that he will not succeed in his quest; but we must again urge that if he does succeed it will be due far more to good luck than to good management. A moral feature of Mr. Edison's "inventions" has just now been brought to light that is of more importance, even, than are the practical matters named, viz., that all the essential details of the electric light as he claims to have perfected it are old discoveries revived or rediscovered after a lapse of more than twenty years. The curious piece of scientific history which we reprint in another column shows how baseless are the claims for originality which he prefers in connection with each of the important features of his electric lighting apparatus; moreover, the failure, practically, of the ingenious system devised by M. Changy for electric lighting amounts to convincing proof that the application of the same system by Mr. Edison must be equally barren of practical results. Let us hope that our American inventor has followed unwittingly in the footsteps of his French predecessor; that in striving to reach the same end he has used unknowingly the same means. This charitable view of the situation is the more necessary because the only alternative presented is to regard this whole electric light business as a cleverly managed stock-jobbing swindle.—*Phila. Times*, Jan 19.

### Gloom in Menlo Park.

There was much surprise among the residents of Menlo Park early last evening, when the little electric jets, that have been glowing constantly in their houses for four weeks, suddenly went out. Even the long chain of street lamps, that reach from Mr. Edison's laboratory to the depot, ceased to reflect from their gracefully modeled globes the effulgence from the little carbon horseshoes within. Menlo Park was in deep gloom. The laboratory and machine shops, however, were as brilliantly lighted as ever. There the electric lights glowed with their usual intensity. A visit to the room in the rear of the great workshop, where the generators are placed, revealed the cause of the darkness without. On Sunday night the wires wound about the armature in one of the dynamo-electric machines became entangled at the commutator. The insulation happening to be defective, fusion took place, and the machine was disabled.

At eight o'clock last evening the machine had been put in complete order, and all the lamps in the houses and street glowed again with their wonted brilliancy. To prevent such accidents in the future, Mr. Edison has decided to wind the wires about the armatures in the dynamo-machines only twice, instead of three times, as has been done before.—*N. Y. Sun*, Feb. 3.

### Killed by the Electric Light.

The London *Times* gives an account of an accident of an extraordinary nature which occurred at the Halte Theatre, Aston, near Birmingham. The stage is lighted by two electric lights, and when the candles are not burning two brass connections, used for the purpose of crossing the current, are hung up over the orchestra. After the performance of the pantomime Mr. A. Bruno, the euphonium player, was leaving with the other members of the band, when, presumably out of curiosity, he caught hold of the two brass connections referred to. The man in charge called out to him with the object of warning him of the danger he was incurring. The warning, however, came too late. Mr. Bruno received the full shock of the electric current generated by the powerful battery which supplies the whole of the lamps in the building and grounds. It is said that the candles not being then burning, Mr. Bruno was unable to disengage himself and pulled the wire down. The shock rendered him insensible. Medical men were soon in attendance and restoratives applied, but Mr. Bruno died in forty minutes afterward.—*New York Herald*, Feb. 4th.

---

Turpentine Varnish.—Clear pale resin, 5 lbs.; turpentine, 7 lbs. Dissolve in any convenient vessel.

THE AMERICAN GAS-LIGHT JOURNAL AND CHEMICAL REPERTORY

A. M. CALLENDER & CO.,

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Editor—G. WARREN DRESSER.

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MONDAY, FEBRUARY 16, 1880.

## Official Report of Examinations of Gas for three Weeks ending Jan. 31, 1880, made at the Photometrical Room of the Department of Public Works.

### Corrected Illuminating Power.

| Jan. 1880. | Time of Day at which Test were made. | New York Gas-Light Co. | Manhattan Gas-Light Co. | Mutual Gas-Light Co. | Metropolitan Gas-Light Co. | Harlem Gas-Light Co. | Municipal Gas-Light Co. |
|---|---|---|---|---|---|---|---|
| 12 | | 18.42 | 18.52 | 22.80 | 19.03 | 18.60 | 28.26 |
| 13 | Between | 19.68 | 18.35 | 22.40 | 20.26 | 18.42 | 26.43 |
| 14 | 9.30 A.M. | 19.42 | 19.01 | 20.82 | 19.86 | 17.22 | 27.10 |
| 15 | and | 19.45 | 18.63 | 20.68 | —— | 16.94 | 30.32 |
| 16 | 1 P.M. | 20.23 | 19.95 | 20.38 | 19.36 | 17.25 | 31.22 |
| 17 | | 20.70 | 19.27 | 21.98 | 18.70 | 16.86 | 30.31 |
| | Average | 19.65 | 18.95 | 21.51 | 19.44 | 17.55 | 28.94 |
| 19 | | 20.35 | 21.07 | 24.18 | 18.30 | 17.04 | 30.14 |
| 20 | | 19 89 | 20.21 | 24.72 | 17.66 | 17.14 | 31.04 |
| 21 | | 20.04 | 20.06 | 25.64 | 18.20 | 17.70 | 31.62 |
| 22 | | 20.13 | 19.85 | 24.59 | 17.01 | 17.01 | 30.34 |
| 23 | | 20.50 | 20.11 | 24.34 | 17.19 | 17.43 | 30.48 |
| 24 | | 19.63 | 19.32 | 23.95 | 17.62 | 17.98 | 30.63 |
| | Average | 20.09 | 20.02 | 24.57 | 17.66 | 17.38 | 30.71 |
| 26 | | 21.30 | 19.92 | 25.32 | 19.94 | 17.97 | 31.95 |
| 27 | | 21.08 | 19.36 | 24.56 | 19.56 | 17 94 | 29.19 |
| 28 | | 21.20 | 20.32 | 22.75 | 18.84 | 17.95 | 30.04 |
| 29 | | 21.90 | 20.26 | 28.66 | 19.13 | 17.68 | 29.66 |
| 30 | | 20.34 | 19.95 | 26.67 | 19.23 | 17.42 | 31.97 |
| 31 | | 17.85 | 20.38 | 25.52 | 18.64 | 17.43 | 29.29 |
| | Average | 20.61 | 20.03 | 25.58 | 19.22 | 17.73 | 30.35 |

E. G. LOVE, Gas Examiner.

## Correspondence

[We are not responsible for the opinions expressed by Correspondents. Correspondents, in all cases, should sign their communications with their names and address in full—not for publiction, unless desired, but as a guarantee of good faith.—ED.]

### Corrections in the Report of Mr. Allen's Remarks on "Water Gas."

*Mr. Editor:*—Please allow me to make some corrections in the report of my remarks before the American Gas Light Association, as published in your JOURNAL of Jan. 2.

In the first column on the fourth page the sentence should read: "By the decomposition of water gas you form hydrogen and carbonic *oxide*" (instead of *acid*).

In the first line of the second column on the same page, the sentence should read: "We have, for instance, two benches for hydrogen *and one for oil, which form a set;*" and in the third line below the sentence should read: "That is *not* the proper way to do it."

In the second line below the last, "That is the fruitful cause of the *loss* [instead of *abuse*] of carbon. We send our hydrogen into the centre *or* oil bench," and omit the words "is near it."

In the third line following the sentence should read: "We pass 100,000 feet per day, [instead of 1,000] from three benches *through one standpipe.*"

But I especially desire to correct the report a little further on, where I was made to say that our company has paid no dividends. I understood the question put to me to have been: "Does your company *pass* [instead of *pay*] any dividends?" and I answered "No, sir."

Respectfully yours,

A. L. ALLEN.

POUGHKEEPSIE, Jan. 29, 1880.

## Gas Pipes and Rats.

A few days ago the household of Mr. Henry Browning, No. 10 Cambridge-gardens, Kilburn Park, were aroused by an escape of gas which filled the drawing room and hall, fortunately before the jets had been lighted. The gas was at once turned of from the main; and, on Mr. Browning returning home, he had the flooring of the drawing room taken up, when a small hole was discovered in the lead piping, and near to this a rat's nest, with young ones. The hole had been drilled out as cleanly as if done by machinery; but it was evidently made by rats.

For several days previous to this the scampering and squealing of rats around the skirting boards had been rather too audible to be pleasant, and the assumtion is that these rats with instinctive nature assumed that the pipes would contain water, and thus used their teeth to obtain a supply. It is possible that rats may have been the means of causing some of the recent explosions in private houses, which have appeared so mysterious.

An effectual remedy for this would be to substitute iron for lead pipes where possible, in conveying gas through private dwellings, as iron would be impenetrable to rat's teeth. Mr. Browning has preserved the leaded gas pipe in which the hole appears, for the examination of the curious.—Lon. *Builder.*

## Houston (Texas) Gas Light Company.

The officers of the above company for 1880 are: T. W. House, Jr., President; T. H. Scanlon, Vice-President; T. F. White, Sec., Treas., and Supt.

IN MEMORIAM.

The committee appointed by the stockholders, at their late annual meeting, to draft suitable resolutions on the death of their late President, T. W. House, made the following report:

WHEREAS, By death we have been deprived at this annual meeting of the Houston Gas Light Company, of the affable and inspiring presence of our most worthy and much-beloved President, the Hon. T. W. House, whose good name and eminent services were foremost among the first in the organization and successful management of this company, and who, from its beginning to the time of his lamented death, a period of more than fourteen years, was its President and chief executive officer; be it therefore

*Resolved*, That in his death each and all of us have lost a warm personal friend, this company its useful and distinguished member, and our community at large its greatest benefactor.

Signed, John T. Brady, Henry S. Fox, T. H. Scanlon, T. F. White, *Committee.*

## Gas Stocks.

### Quotations by G. W. Close Jr., Broker and Dealer in Gas Stocks. (with W B Scott & Co.,)

24 PINE STREET, NEW YORK CITY.

FEBRUARY 16, 1880.

☞ All communciations will receive particular attention

☞ The following quotations are based on the par value of $100 per share.

| | *Capital.* | *Par.* | *Bid.* | *Asked.* |
|---|---|---|---|---|
| *Gas Co.'s of N. Y. City.* | | | | |
| Central | 466,000 | 50 | 45 | 55 |
| Harlem | 1,800,000 | 50 | 42 | 47 |
| " Bonds | 170,000 | | | 103 |
| Manhattan | 4,000,000 | 50 | 158 | 160 |
| Metropolitan | 2,500,000 | 100 | 118 | 122 |
| " Scrip | $1,000,000 | .. | 95 | 100 |
| Mutual | 5,000,000 | 100 | 55 | 60 |
| " Bonds, gold | 900,000 | 1000 | 95 | 100 |
| Municipal | 1,500,000 | 100 | 160 | — |
| " Bonds | 750,000 | | 106 | 110 |
| New York | 4,000,000 | 100 | 97 | 101 |
| Northern | 270,000 | 50 | — | 100 |
| *Gas Co's of Brooklyn.* | | | | |
| Brooklyn | 2,000,000 | 25 | 110 | 120 |
| Citizens | 1,200,000 | 20 | 50 | 55 |
| " S. F. Bonds. | 320,000 | 1000 | 100 | 102 |
| Peoples | 1,000,000 | 10 | 25 | 30 |
| " Bonds | 290,000 | .. | -- | 95 |
| " Scrip | 250,000 | ... | 75 | 80 |
| Metropolitan | 1,000,000 | 100 | 60 | 70 |
| Nassau | 1,000,000 | 25 | 50 | 60 |
| " Ctfs. | 700,000 | 1000 | 80 | 85 |
| Williamsburgh | 1,000,000 | 50 | 70 | 75 |
| " Scrip | | ... | 97 | 101 |
| Kings Co | 135,000 | 100 | — | 50 |
| " Bonds | 40,000 | — | — | — |
| Union Co. E. N. Y. | | 25 | — | 50 |
| Richmond Co., S. I. | 300,000 | ... | — | 85 |
| *Out of Town Gas Companies.* | | | | |
| Bath, Maine | 70,000 | 100 | | |
| Buffalo Mutual, N.Y | 750,000 | 100 | 65 | 70 |
| " Bonds | 200,000 | 1000 | 95 | 100 |
| Baltimore, Md | 2,000,000 | 100 | 95 | 98 |
| " Ctfs., gold | 1,000,000 | | — | 103 |
| Bayonne, N. J | | 100 | | 90 |
| Brockport, N. Y | 25,000 | 100 | ... | 80 |
| Citizens, Newark | 918,000 | 50 | 92½ | 90 |
| " " Bds. | 124,000 | — | 105 | 10 |
| Chicago Gas Co., Ills | | | 125 | — |
| Cincinnati G. & C. Co. | | | | 190 |
| Derby of Conn | 160,000 | 100 | 60 | 80 |
| East Boston, Mass | | 25 | 114 | 120 |
| Elizabethtown, N. J. | 300,000 | 20 | — | 130 |
| Fort Wayne, Ind. | | 100 | ... | — |
| Hannibal, Mo | 100,000 | 100 | 95 | 100 |
| Hartford, Conn | 700,000 | 25 | 120 | 125 |
| Hempstead, L. I. | 25,000 | 100 | ... | — |
| Halifax N. S. | 400,000 | 40 | 148 | 150 |
| Hamilton, Ontario | 150,000 | 40 | 117½ | |
| Jersey City | 750,000 | 20 | 140 | 145 |
| Jamaica, L. I. | 25,000 | 100 | ... | — |
| Jacksonville, Ill | 120,000 | 50 | 100 | ... |
| Lewistown Maine | 400,000 | 100 | 70 | 80 |
| Laclede St Louis Mo. | 1,200,000 | 100 | 100 | 105 |
| Long Branch | | 20 | 30 | 40 |

| | | | | |
|---|---|---|---|---|
| New Haven, Conn... | | 25 | 120 | 140 |
| Peoples, Jersey City | | ... | 40 | 50 |
| " " Bds. | | | | 95 |
| Peoples of Albany... | 650,000 | 100 | — | 10 |
| " Bonds | 350,000 | 1000 | — | -- |
| Peoples of Baltimore | | 25 | 60 | 65 |
| " Bonds.... | | | 106 | — |
| Plainfield, N. J..... | 80,000 | 100 | — | 105 |
| Perth Amboy ..... | | 25 | — | 95 |
| Pittsfield, Mass..... | | | 120 | 130 |
| Rochester, N. Y..... | | 50 | 70 | 80 |
| " Citizens | | 100 | 50 | 60 |
| Rondout & Kingston | | | 75 | 80 |
| St. Louis Missouri.. | 600 000 | 50 | 300 | — |
| Stillwater, Minn..... | 50,000 | 50 | — | 26 |
| Saugerties, N. Y.... | 15,000 | 100 | 95 | 100 |
| San Francisco Gas-Co., S. Fr'isco Cal. | | | 95 | 95½ |
| Toledo, Ohio..... | | | 95 | 97 |
| Troy, Citizens.. ..... | 600,000 | 100 | — | 60 |
| Washington, D. C... | 1,500,000 | 20 | 170 | 185 |
| " Scrip | 500,000 | 20 | 100 | 110 |
| Woonsocket, R. I.... | 150,000 | 100 | 80 | ... |
| Wilmington, Del.... | | 50 | 174 | ... |
| Yonkers..... | | 50 | — | 70 |

The Metropolitan Company have paid their regular dividend of 5% on stock and 3½% on scrip.

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**Youghiogheny Gas Coal.**

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The notice given it in the last issue of the stationer journals of this city in their novelty columns will be sufficient to commend it to general investigation. Accompanying cut shows the file with top removed, in process of binding.

Says the *American Stationer:* "This novelty is strong and durable, and its title is not inappropriate. It is destined to find its way into every systematic counting room in the country."

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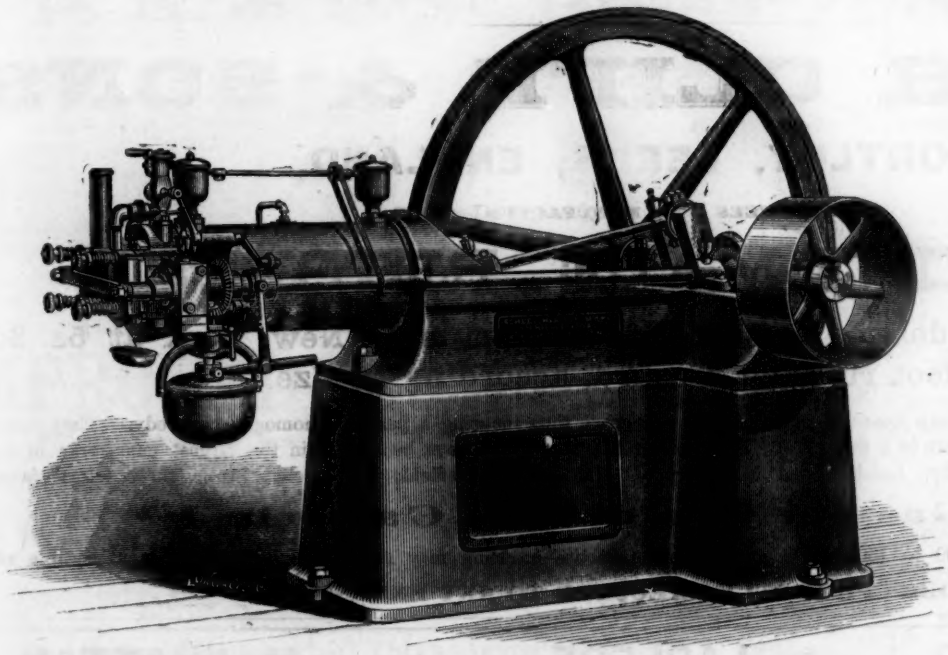

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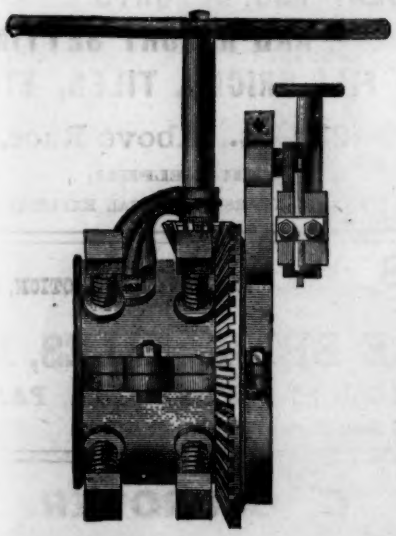

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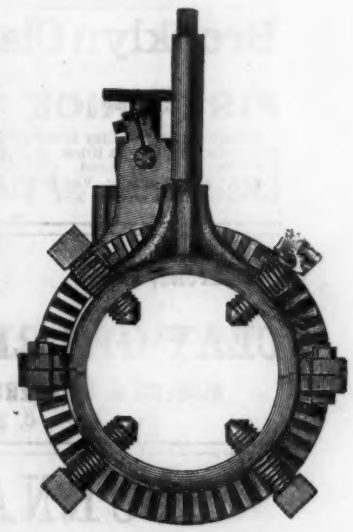

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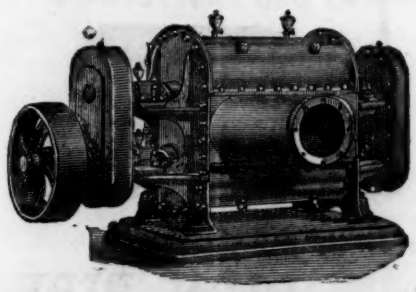

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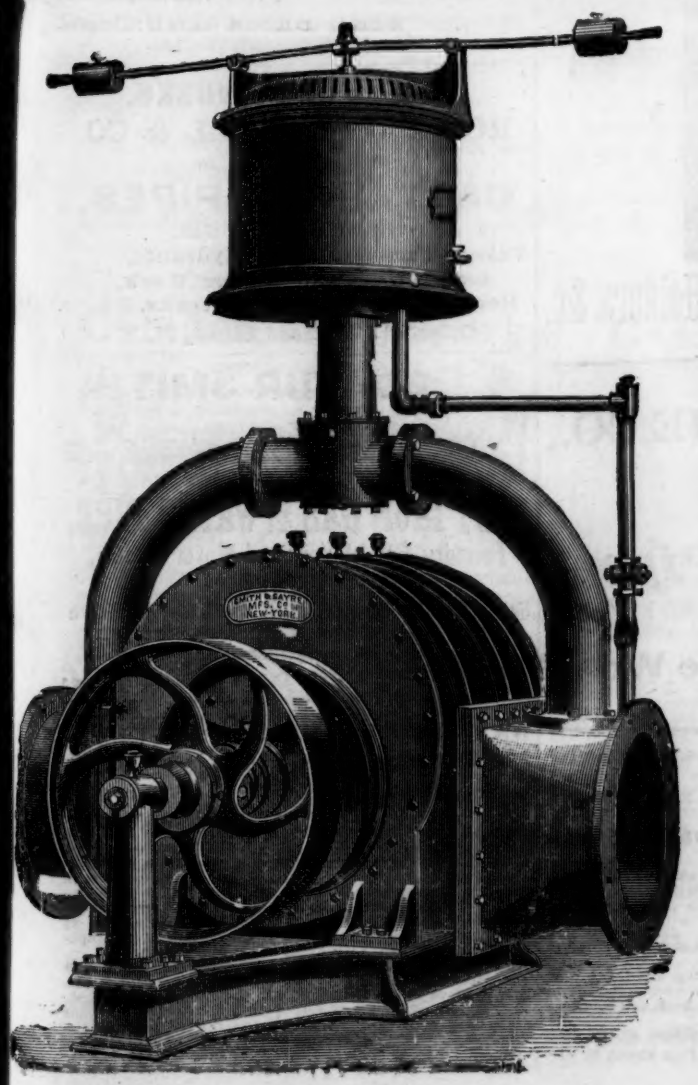


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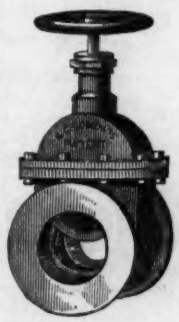

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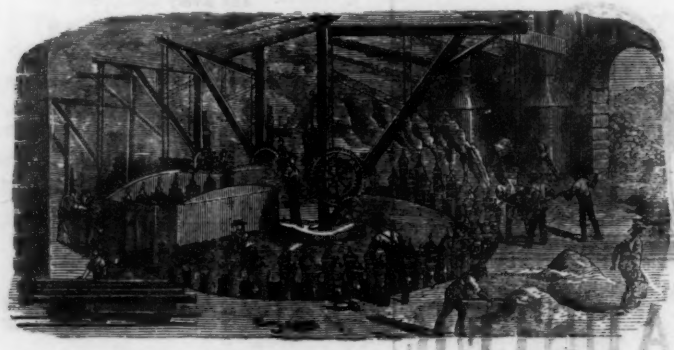

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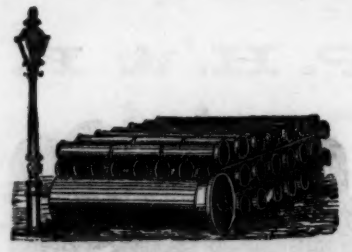

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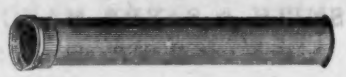

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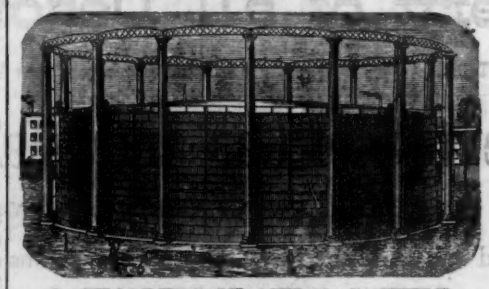

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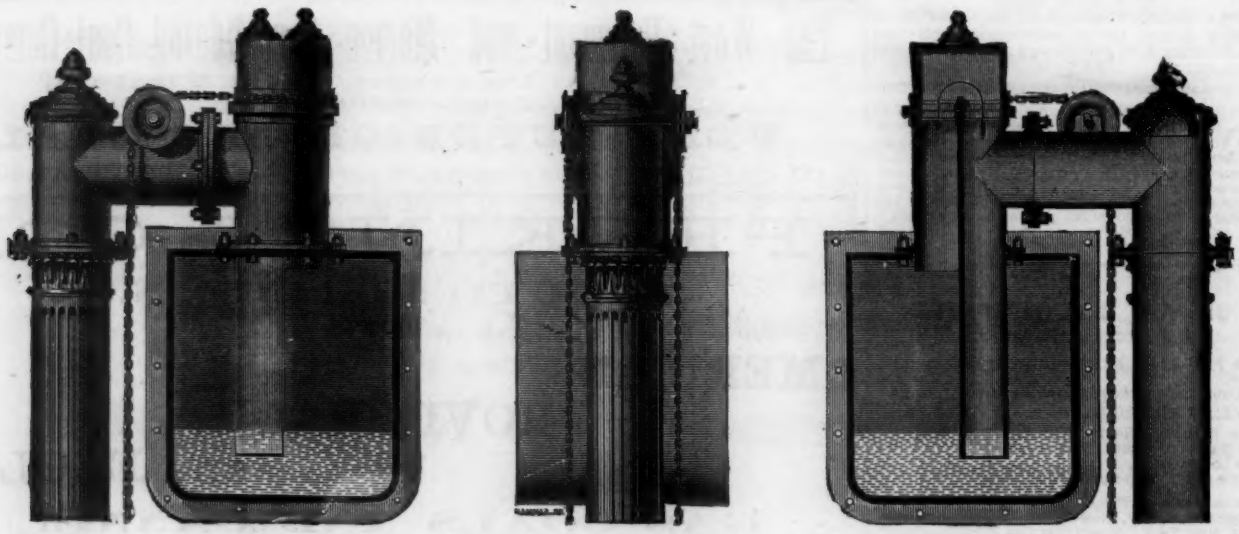

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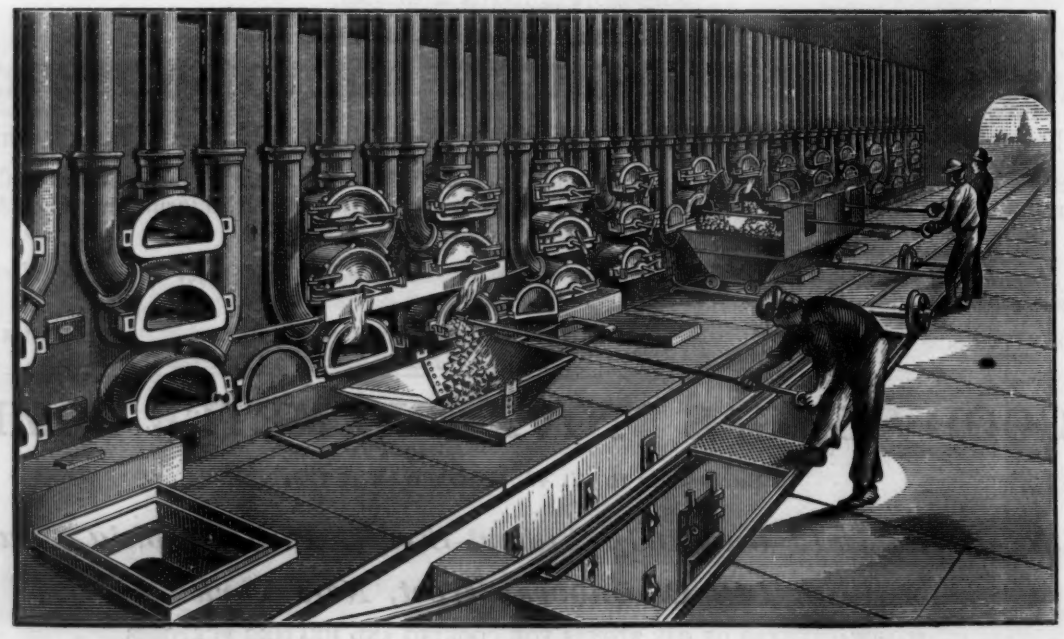

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